Copy No. _____

Defence Research and Development Canada   Recherche et développement pour la défense Canada

DEFENCE R&D DÉFENSE

Underwater Sensor System 2009 Field Trial Report

Northern Watch Technology Demonstration Project

Garry J. Heard
Nicos Pelavas
Gordon R. Ebbeson
Dan L. Hutt
Isaias Peraza
George Schattschneider
Derek Clark
Val Shepeta
Jacques Rouleau

Defence R&D Canada – Atlantic

Technical Memorandum

DRDC Atlantic TM 2010-241

March 2011

Canada

This page intentionally left blank.

Underwater Sensor System 2009 Field Trial Report

Northern Watch Technology Demonstration Project

Garry J. Heard
Nicos Pelavas
Gordon R. Ebbeson
Dan L. Hutt
Isaias Peraza
George Schattschneider
Derek Clark
Val Shepeta
Jacques Rouleau

Defence R&D Canada – Atlantic

Technical Memorandum
DRDC Atlantic TM 2010-241
March 2011

Principal Author

Original signed by Garry J. Heard

Garry J. Heard

Approved by

Original signed by Paul Hines for

Daniel L. Hutt

Head, Underwater Sensing

Approved for release by

Original signed by Ron Kuwahara for

Calvin Hyatt

Chief Scientist, DRDC Atlantic

Abstract

This document provides an overview of the summer 2009 field trial conducted at Gascoyne Inlet on Devon Island, Nunavut. The trial was carried out as part of the effort related to the Northern Watch Technology Demonstration Project. This report describes the progress against the objectives of the field trial and is intended to serve as a reference to the Gascoyne Inlet field camp, which was greatly improved and extended during this field trial. The main scientific objective of the trial was the deployment of two underwater sensing arrays in Barrow Strait. The deployment was successfully completed and sizeable quantities of valuable data were collected. Unfortunately, the underwater arrays suffered a mechanical issue that allowed water to penetrate and render them inoperable after a period of time. It had been the intention that these arrays would be reactivated in future field trials at this location.

Résumé

Le présent document résume les essais sur le terrain réalisé à l’été 2009 à Gascoyne Inlet, sur l’île Devon, au Nunavut. Les essais ont été effectués dans le cadre des activités liées au projet de démonstration de technologies (PDT) de surveillance du Nord. Le document décrit les progrès accomplis en fonction des objectifs des essais sur le terrain et vise à constituer une référence pour le campement de Gascoyne Inlet, qui a été beaucoup amélioré et agrandi pendant les essais sur le terrain. L’objectif scientifique principal des essais était le déploiement de deux réseaux de détection sous-marine dans le détroit de Barrows. Le déploiement a bien réussi, et des quantités importantes de données précieuses ont été recueillies. Malheureusement, les réseaux sous-marins ont eu des problèmes mécaniques qui ont permis la pénétration d’eau et les ont rendus inopérants après un certain temps. Nous espérons que ces réseaux seront réactivés pour d’autres essais sur le terrain à cet endroit.

This page intentionally left blank.

Executive summary

Underwater Sensor System 2009 Field Trial Report: Northern Watch Technology Demonstration Project

Garry J. Heard, Nicos Pelavas, Gordon R. Ebbeson, Dan L. Hutt, Isaias Peraza, George Schattschneider, Derek Clark, Val Shepeta, Jacques Rouleau; DRDC Atlantic TM 2010-241; Defence R&D Canada – Atlantic; March 2011.

Introduction or background: Defence Research and Development Canada is conducting a Technology Demonstration Project (TDP) called Northern Watch. This major project has an objective of demonstrating a suite of sensors for Arctic chokepoint surveillance. This document describes the deployment of an underwater sensing system in Barrow Strait along with the subsequent detections of vessels of opportunity. In addition, the extensive developments in infrastructure required to support underwater array operations in a remote Arctic location are documented.

Results: The summer 2009 field trial has resulted in a significant improvement in the condition of the field camp that will be used as a base of operations throughout the life of the TDP. Valuable Automatic Identification System (AIS) data were collected during the field trial from cooperating vessels and contacts of opportunity. The underwater sensing system was successfully deployed. Techniques were developed to allow accurate future deployments and to allow servicing and recovery of deployed systems. The underwater arrays operated for a period of approximately two weeks during which time they were slowly degrading due to water ingress. The concept of operation was proven by the data that were collected. Unfortunately, the water ingress, which appears to be due to a materials issue in the array construction, resulted in the arrays becoming inoperable. The existing foreshore pipe that protects cables from abrasion by the ice was shown to be useable, but the lower end was found to have been covered by gravel that must be cleared away.

Significance: The trial has cleared the way for future operations at the Devon Island site. The field camp has been developed to the point where it is a safe and comfortable base for the field workers to operate from. The concepts of using the AIS and underwater sensors were shown to be practical and very useful. Valuable data were collected to aid in performance prediction of the AIS and underwater arrays.

Future plans: The Northern Watch TDP is currently under-going a complete review and is expected to continue until at least 2014. In the subsequent years a full suite of sensors will be deployed and data will be linked to a southern receiving location. Current plans call for the sensor suite to operate for a full year in an unattended mode. During the summer of 2010 it is planned that divers will clear the gravel from the underwater end of the foreshore pipe and the already deployed cables will be threaded through the pipe in preparation for future operations.

Sommaire

Underwater Sensor System 2009 Field Trial Report: Northern Watch Technology Demonstration Project

Garry J. Heard, Nicos Pelavas, Gordon R. Ebbeson, Dan L. Hutt, Isaias Peraza, George Schattschneider, Derek Clark, Val Shepeta, Jacques Rouleau; DRDC Atlantic TM 2010-241; R & D pour la defense Canada – Atlantique; mars 2011.

Introduction : Recherche et développement pour la défense Canada a réalisé un projet de démonstration de technologies (PDT), appelé Surveillance du Nord. Ce projet important vise à faire une démonstration d'un réseau de capteurs pour la surveillance d'un point de passage dans l'Arctique. Le document décrit le déploiement d'un réseau de détection sous-marine dans le détroit de Barrows, ainsi que les détections subséquentes de navires de passage. Il présente en outre les grands déploiements d'infrastructures nécessaires à l'appui des opérations du réseau sous-marin dans une région arctique éloignée.

Résultats : Les essais sur le terrain réalisés à l'été 2009 se sont traduits par une amélioration importante des conditions dans le campement qui servira de base d'opérations pour la durée du PDT. Des données précieuses pour le Système d'identification automatique (SIA) ont été recueillies pendant les essais sur le terrain et proviennent de navires coopérants et de contacts de passage. Le système de détection sous-marine a été déployé avec succès. Des techniques ont été développées pour permettre d'autres déploiements précis, ainsi que l'entretien courant et la récupération de systèmes déployés. Les réseaux sous-marins ont fonctionné pendant environ deux semaines, au cours desquelles ils se sont progressivement dégradés en raison d'entrée d'eau. Le concept d'opération a été démontré par les données recueillies. Malheureusement, l'entrée d'eau, qui semble être due à un problème de matériaux dans la construction du réseau, a rendu les réseaux inopérants. Le tuyau en place sur l'estran et qui protège les câbles contre l'abrasion de la glace s'est avéré utile, mais l'extrémité inférieure était couverte de gravier qui doit être enlevé.

Portée : Les essais ont ouvert la voie à d'autres opérations au site de l'île Devon. Le campement a été développé à un point tel qu'il est devenu une base sécuritaire et confortable pour les travailleurs sur le terrain. Les concepts d'utilisation du SIA et de réseaux sous-marins se sont avérés pratiques et très utiles. Des données précieuses ont été recueillies pour aider à prévoir le rendement du SIA et des réseaux sous-marins.

Recherches futures : Le PDT de surveillance du Nord fait l'objet d'un examen complet et devrait se poursuivre au moins jusqu'en 2014. Dans les années qui suivront, une gamme complète de capteurs seront déployés, et des données seront acheminées à un emplacement de réception au sud. Les plans actuels exigent que la gamme de capteurs fonctionne pendant une année complète en mode sans surveillance. À l'été 2010, on prévoit que des plongeurs enlèveront le gravier de l'extrémité immergée du tuyau sur l'estran, et que les câbles déployés seront passés dans le tuyau en vue d'opérations futures.

Table of contents

List of figures

List of tables

Acknowledgements

We would like to give our thanks to the personnel of the Canadian Coast Guard, the Polar Continental Shelf Program, and the members of all DRDC groups who provided incredible support to this project. This field trial required an amazing amount of effort. Without the full support of Management, Purchasing, Stores, Model Shop, and many others this trial could never have left the building. Also, a special thanks to Nelson McCoy who worked hard to see this trial become a success.

This page intentionally left blank.

Overview

The second Arctic trial for the Northern Watch (NW) Technology Demonstration Project (TDP) was conducted from 30 June to 4 September, 2009. The location for the trial was Gascoyne Inlet on the south-western corner of Devon Island, Nunavut. Gascoyne Inlet is about 100 km east of Resolute and is located at the single most important choke point of the Arctic Archipelago (Queen Elizabeth Islands).

The purpose of the NW TDP is to identify and describe combinations of systems for cost effective surveillance of the Canadian Arctic. The project includes plans to evaluate the suitability of various vessel-monitoring sensors and systems at a Northwest Passage chokepoint. All of the field trials for the project will take place on Devon Island and in Barrow Strait. However, modelling studies may cover other Arctic choke point locations.

This year, the activities included the improvement of the field camp and the installation and operation of the underwater sensors. Two bottom-mounted arrays that include passive acoustic, magnetic, and electric field sensors were deployed in Barrow Strait and were operated via a shore cable from the field camp at Gascoyne Inlet.

The overall objectives of the second Northern Watch main trial were:

1. Continue the improvement of buildings and other camp infrastructure,
2. Recover the existing 9-km long backbone shore cable deployed previously,
3. Deploy two underwater sensor arrays and shore cables,
4. Localize the underwater arrays,
5. Clean out and make use of the existing foreshore cable protection pipe,
6. Collect sensor data on vessels of opportunity,
7. Collect sensor data on co-operative vessels,
8. Collect environmental data,
9. Collect ambient noise data,
10. Collect transmission loss data,
11. Establish and test satellite communications connectivity with the South,
12. Collect power usage and generation data for support to long-term power plans,
13. Improve arctic experience and training level for participants, and
14. Deploy a Bedford Institute of Oceanography (BIO) underwater cable.

It will be shown that all of these objectives were met. We also succeeded in developing techniques for successful array system deployment and recovery operations that will facilitate future operations and we have forensic results from the year-long deployment of the first 9-km cable and repeaters. Overall the trial was a considerable success; however, we had a devastating blow in the failure of the two deployed arrays and in the spare array. Two of the

arrays were recovered and one of these has been given an initial inspection. The cause of array failure has been determined to be a materials issue.

Figure 1. A view from the Gascoyne Inlet camp. Low-lying fog is common and while photogenic it is a hindrance to operations.

Trial Team

Dr. Garry J. Heard	Chief Scientist (OIC)	DRDC Atlantic
Gordon R. Ebbeson	Scientist	DRDC Atlantic
Dr. Nicos Pelavas	Scientist	DRDC Atlantic
Dan Wile	Mechanical Technologist	DRDC Atlantic
Sean O'Grady	Mechanical Technologist	DRDC Atlantic
Jacques Rouleau	Electronics Technologist	DRDC Atlantic
Jim Milne	Logistics Officer	DRDC Atlantic
Al Tremblay	Electronics Technologist	DRDC Atlantic
Derek Clark	Computer Specialist	DRDC Atlantic
Dr. Dan Hutt	Head, US Section	DRDC Atlantic
Val Shepeta	Electronics Technologist	DRDC Atlantic
Isaias Peraza	Engineer	DRDC Atlantic
LCdr Bruce Grychowski	Project Manager	DRDC Atlantic
Greg Van Slyke	Electronics Engineer	Omnitech Electronics Inc.
A.J. Taylor	Cook	Augustus Taylor Consulting
Eric Durling	Camp Security	EMD Security Services

Figure 2. Group picture of most of the camp participants.

Schedule

30 Jul Heard travels to Ottawa for meetings.

31 Jul Milne, Wile, O'Grady, Clark, Tremblay travel to Ottawa and begin work at First Air who are loading a chartered Inuit Air 737.

1 Aug Hutt, Rouleau, Pelavas, and Durling arrive in Ottawa. Milne departs for Resolute.

2 Aug Taylor, Hutt, Rouleau, Pelavas, Durling, Heard, Wile, O'Grady, Clark, and Tremblay board the chartered Inuit Air 737 for Resolute.

3 Aug Taylor, Hutt, Rouleau, Pelavas, Durling, Heard, Wile, O'Grady, Clark, and Tremblay arrive at Gascoyne Inlet camp. Camp set up begins.

6 Aug Ebbeson, Van Slyke, and Shepeta travel to Ottawa. Camp set up continues.

7 Aug Ebbeson, Van Slyke, and Shepeta fly to Resolute. Camp set up continues.

8 Aug Ebbeson, Van Slyke, and Shepeta fly to Gascoyne Inlet. Camp set up and array testing continue.

9 Aug *CCGS Terry Fox* arrives on station one day earlier than expected. Ship is well into preparations for array cable recovery.

10 Aug Recovery team boards *Terry Fox* and recovers first 3-km section of the old cable.

11 Aug Recovery team successfully recovers the remaining 6 km of cable. An assessment of the cable components is carried out.

12 Aug to 19 Aug *Terry Fox* array deployments and recoveries take place. Ship runs, AEL, environmental and propagation loss measurements are made.

20 Aug Grychowski and Peraza travel to Ottawa. Clark leaves camp to return home.

22 Aug Array operations end. Clark flies home. Grychowski and Peraza fly to Resolute.

23 Aug Grychowski and Peraza fly to Gascoyne Inlet. Wile, O'Grady, Hutt, and Van Slyke fly to Resolute. Foreshore pipe clearing operations, data analysis, and camp improvement become main efforts.

24 Aug Wile, O'Grady, Hutt, and Van Slyke return home.

25 Aug to 31 Aug Camp operations, pipe clearing, data analysis, and close out preparations take place.

1 Sep Remaining personnel return to Resolute.

2-3 Sep Gear is prepared for shipment to Resolute and Dartmouth. Taylor returns home.

4 Sep Remaining personnel return home.

Summary of Outcomes

In this section, each of the objectives of the field trial are discussed and the results are provided to illustrate what was achieved.

Continue the improvement of buildings and other camp infrastructure

Considerable improvements were made to the camp infrastructure during this trial and a camp building expedition that took place just prior. The camp is now a significant assembly of buildings that will provide comfortable accommodations for up to 16 people. Not only is there clean, warm, and comfortable sleeping arrangements, but the camp now includes household electricity, lights, and appliances. In addition, both the washing area and kitchen have hot and cold running water, sinks, and drains. Significant improvement to the heating of the buildings has been made throughout the camp.

Figure 3. A view of the camp from the inlet at about the mid-point of the trial.

The sanitary facilities have been dramatically improved. They are clean, comfortable, and private. The washing area now provides two fully operational shower stalls with pressure balanced faucets to insure even temperature water under varying supply demand. There are two washing rooms that provide mirrors, light fixtures, steel sinks, and heat. There is also a full-size dedicated laundry tub.

Only a female-use urinal is required to complete the camp sanitary facilities. This feature can be added during the next visit to the area.

No other research organization Arctic camps provide facilities of this quality. Word has already spread about the existence of the showers and practically unlimited hot water. These are unusual luxuries in short-term scientific field camps, but they add significantly to the safety, health, and welfare of camp participants.

In addition to the improvements already described, the camp now has an almost complete coat of paint. Red, white, and grey predominate the colour scheme. A giant Canada Flag decorates the side of the largest building and provides an impressive greeting to visitors approaching by

air or sea. The camp also has three flag poles, which display full size Canada, Nunavut, and DRDC flags.

An impressive and very successful electronic bear fence encloses the entire camp. Helicopters can land within the space delineated by the fence. The fence consists of ninety-five wooden posts mounted on wooden plates that are dug into the ground at 10-foot intervals and covered with gravel. Each post has four, 10-foot long steel-cable wires that terminate in a double banana plug at the free end. The other end of the cables are clamped beneath aluminium discs and spring-steel clamps. The cables are strung between the poles at different heights between 0.20 and 2.0 m. Slack is taken up by wrapping the cable a couple of times around the disc and then pulling the cable underneath the steel spring clamp. The dual banana plug coupling forms a re-joinable weak link that pulls apart when the steel cable is pulled. The wires form a normally-closed loop through which a small sensing current flows. When any of the couplers open, current stops and an alarm is triggered. The alarm is provided by four large Sonalert buzzers mounted on an elevated wooden post in the camp. A control system and PA system complete the bear fence, which detects an intrusion into the camp area.

This fence significantly improves camp security and has operated extremely well. Only 3 false alarms were generated during the trial. These false alarms were caused by the wind blowing a cardboard box or other loose item through the fence. A number of other false alarms were generated by people trying to climb through the fence without turning it off. In the future, three gates will be added that will allow people to enter or leave the camp without disabling the alarm. A garbage box will be built to contain loose cardboard and bags to ensure that they are safe from animals and unable to blow around.

The fence successfully detected the intrusion of rabbits into the camp on several occasions. Only fox and lemmings are able to penetrate the fence without detection. Because the fence can be triggered by small animals, we plan to add a separate alarm signal to indicate a break of the lower wire barrier. Bears are not likely to be able to enter the camp without pulling out two or more rows of cable.

The bear fence was expensive in both materials and set up time; however, it is functioning extremely well and has provided a strong sense of security. The fence is superior to anything commercially available and attracted the attention of a visiting Wildlife Officer who would like a similar device for the garbage dump at Resolute.

Figure 4. A view of some of the 95 posts that comprise the bear fence. The banana plug couplers and the aluminium disc with spring-steel clamps are clearly visible on the foreground post.

All camp buildings have been numbered G1 through G9 and will have signs posted to make clear which building is which. A complete survey of the camp was undertaken and an accurate map of the camp is in production. Upgrades have been made on all structures, including the generator hut, but excluding the ATCO trailer. Annex A provides a survey map of the camp and Annex B shows plan views of all structures at the camp. Annex C contains photographs of each camp building.

The old X-Hut (now known as building G6) functions as a water treatment facility and provides 2 washing rooms, 2 showers, a laundry area, and a stores area. The water is brought to the building via gravity feed using an ABS plastic pipeline from a stream some 500 m inland from the camp. The electrical panel in this building should be replaced.

The old F-Hut (building G5) has been completely refurbished and now provides choice accommodations for three personnel. The electrical distribution panel in this hut requires replacement.

The old and failing storage “tent” (building G9) has been completely rebuilt and provides secure and dry storage.

An approved portable incinerator facility has been installed and has significantly reduced the need to back haul garbage and increased safety by completely burning food scraps.

The generator hut and toilet area (building G3) require more improvements. These will be made in the near future. The most significant improvement is the repair of the Lister diesel generator, which failed on the first day at camp. The Lister is an old machine, but one of high quality. The failure was caused by a cracked fuel injector that can be easily replaced. The camp ran on two 5.5 kW Yanmar portable diesel generators, but these should be built into an expanded generator shed and used primarily as backup systems. In addition, the Lister generator breaker switch and output wiring as well as the electrical distribution panel are in need of a complete replacement. Annex D provides a summary of the camp electrical.

A used, but very serviceable Lister generator was acquired at the end of the trial. The Lister was in Resolute and was headed for Crown Assets disposal. This machine is ideal for use at Gascoyne Inlet and has been retained for the project. This machine requires servicing and installation in the generator hut.

Remaining work includes a much required rebuild of the kitchen (building G8) and the inclusion of an eating area. This new large structure can also include a much improved communications centre and serve as a place for meetings, social gatherings, and relaxation. Several briefings were necessary during the camp operational period. It was difficult to hold these briefings as there was no suitable location where everyone could be in one building. Outside conditions were good during this trial, but are frequently not suitable. A larger, sheltered space will serve to increase productivity.

Finally, the ATCO trailer (building G7) should either be upgraded or replaced with a new accommodation structure. This last structure is primarily intended for the camp cook. It is common in field camps to maintain a private area for the cook since they keep long and irregular hours and may be of either gender. A separate accommodation is required by female participants and does not currently exist at the camp. By building a larger partitioned structure we will have better opportunity to provide accommodations for female participants without significantly reducing the camp crew size.

Recovery of the existing 9-km long backbone cable

The 9-km array shore cable that was deployed in 2008 was completely recovered. Before recovering the cable, electronic tests were conducted and it was determined that the cable and repeater nodes were all operating in exactly the same condition as they were when we left last year. The cable was fully operational except for one high-speed telemetry channel that was intermittent. This problem developed on deployment last year.

We had attributed this telemetry problem to one of the DSL modems in the final repeater node, known as the Array Junction Box (AJB). In order to combat this failure we designed multiple redundancies into the array backbone cables for this year. In addition, the commercial DSL components were “burned in” by running them in elevated temperatures for extended periods. This burn-in period increased the certainty that the modems would continue to operate properly. Looking ahead for a moment, it must be noted that the DSL modems in the repeaters are a weak point in the system. One of the pre-tested and burned in modems did fail prior to deployment and was replaced.

On recovery of the cable we discovered that the “pigtail” portions of the cable had been partially eaten by marine life. One of the pigtails was eaten to point that some copper was exposed to the seawater. This particular problem could also have been caused initially by abrasion and then being nibbled by critters.

Observation showed that vinyl tape covered regions were unaffected by the nibbling. We covered the pigtails in the new deployments with tape to ensure a longer life time. We also added additional protection to couplings to avoid abrasion problems as much as possible.

Figure 5. Rubber pigtail that has been partially eaten by sea life.

Figure 6. Copper wires were exposed on one part of the recovered cable. It is uncertain if the cause was abrasion or nibbling by sea life.

The recovered repeater nodes showed significant corrosion. Despite the all stainless steel construction of the support cages, corrosion of certain parts was excessive. There are a number of small collars that hold the canisters in position within the stainless steel cages. All of these collars were significantly damaged. Several were missing completely. Significant corrosion was also seen at steel mating surfaces. The rate of the corrosion was much higher than expected and may indicate lower than normal oxygen content in the water.

Figure 7. Stainless steel retaining collars were all severely damaged by corrosion. Several were missing completely.

Figure 8. Stainless steel corrodes where oxygen is excluded. This typically occurs at mating surfaces as seen here.

By examining the corrosion we have learned some valuable lessons and can now design cages with longer structural lifetimes. We estimate that the mechanical integrity of the existing cages will be lost within three years. The design goal was two years. While the loss of structural integrity would make system recovery difficult, it is not likely to prevent the cable system from operating electronically. The electronics canisters were all plastic and showed no appreciable wear.

During the recovery of the cable we used a large diameter powered reel and a dumb barge pushed by an SP barge from *Terry Fox*. This mechanism and vessel combination worked extremely well. It is a reliable mechanism for recovery of the cable and can be used in low sea

states with good success. A purpose built system of similar, but faster operation would be ideal for cable recovery operations.

Figure 9. A dumb barge with safety stanchions attached is lashed to an SP barge at rear.

Deployment of two underwater sensor arrays and cables

Array Deployment

During the field trial we deployed three arrays. Array 1 was deployed in 175-m deep water, Array 2 was deployed in 120-m deep water, and Array 3 was used to replace Array 1 when it failed.

The deployment plan called for the use of two independent cables, one from each array, running back to shore. The arrays were to be deployed approximately 6-km apart as shown in the plan below (Fig. 10). The array was deployed first and then the cable was laid to shore. The arrays were successfully deployed within a few meters of the planned locations and the cable tracks followed the planned route with great accuracy. By monitoring the amount of cable laid and distance run we ensured an accurate lay and that the proper amount of cable would be left over when the shore was reached.

The deployments were carried out using the dumb barge and SP barge combination. The SP barge was driven backwards throughout the entire deployment of the array and cables.

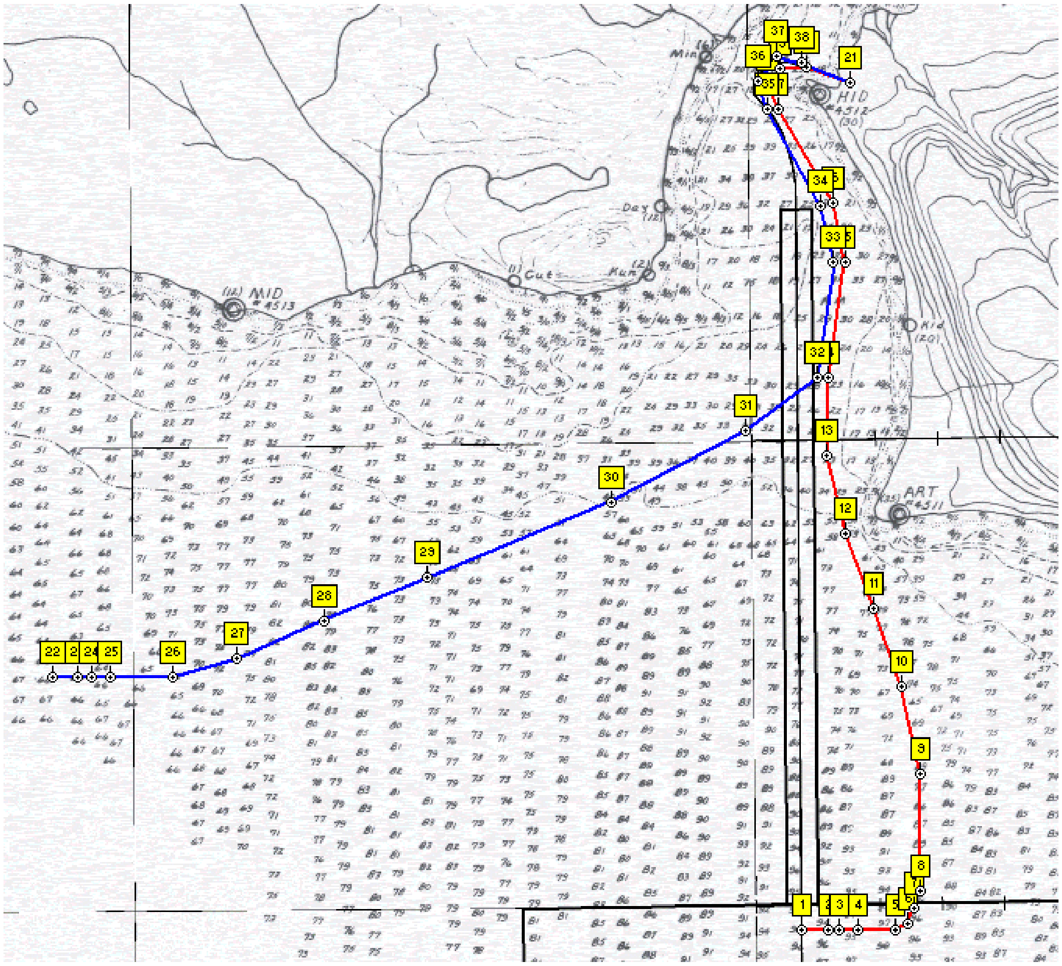

Figure 10. The deployment plan. Arrays1 & 3 were deployed at waypoints 1-5, Array 2 was deployed at waypoints 22-26. The cable routes to the camp followed the deepest water in the shallow regions.

The array components were flaked on deck and hand deployed under tension while the length of system paid out and the motion of the vessel was tracked using GPS. This constant comparison and control is required to ensure a straight stretched out lay of the array and to ensure that the array is not dragged too far. It also ensures that the cable is laid as expected and not simply being dragged out by the current flow.

Figure 11. Dan prepares one of the cable nodes for deployment. Note the cable reels that were used to hold the independent cable sections.

Figure 12. Al deploys an array by hand using the large diameter pulley at the front of the barge.

The main cable was deployed from the wooden cable spools on which the cable was delivered. Jack stands were welded into frames to support the reels on the barge. Batteries and wireless array controller systems were attached to the sides of the reels to allow real-time monitoring of the array condition during deployment.

Figure 13. A view of the unpowered cable reels mounted on the jack stands. Note the wireless, battery powered array controller systems on the cable reels. The wireless systems allowed continuous confirmation that the array was functional during deployment.

Figure 14. A Northern Watch array flaked out for deployment on the deck of the dumb barge. The cable reels are at the far end of the deck.

The tasks of deployment were broken into the following jobs. Boat driver, Mate, array/cable handlers, and navigator. Extra people were on board to allow people to be relieved and also to lay hands as required should the need arise. The boat driver was the Chief Mate of the *CCGS Terry Fox*. He drove the vessel under the influence of instructions from the Mate and the navigator. The Mate watched the cable lay and kept the vessel aligned by verbal instruction to the driver. The Mate also watched for safety issues and kept control of the deck. The cable/array handlers lifted the array components over the side, released or held the cable as required, assembled the repeaters, coupled the cables, and moved batteries and wireless units as necessary. The navigator was responsible for ensuring that the position and progress of the

lay was as planned. This was done by continuous use of GPS, mapping software, and monitoring of all cable lengths.

Array 1 was deployed almost at the intended position, but was paid out too quickly while the vessel was not making sufficient headway into the current. We held tension and the array was dragged to the proper position. The array, which was later recovered, showed scuff marks from the dragging, but did not suffer any significant damage from this action.

Array 2 deployment began about 100-m west of the intended location and was originally deployed too quickly. We held the array before it entered the water dragging the anchor line and UEP cable out straight. The array was released at the proper location and tension held. The lengths were coordinated well with the vessel motion and the significant marker points lined up well with the planned locations.

Array 3 was used to replace the failed Array 1. This last array was deployed in the opposite direction from the others as the cable was already in place. We attached the array extender cage to the main telemetry cable and lowered it first. The array was then paid out as the vessel moved away. Unfortunately, the navigation computer locked up and died at the critical moment. By the time the backup unit was in play the array was deployed except for the anchor line. At this point it was clear that the vessel had not made headway against the wind and current. The result would be an array piled up on itself – or very nearly. We began to drag the array into position with the anchor line. This was risky, but really the only option as the drag and tension on the lines were excessive and without the powered recovery reel it is unlikely that we could recover the array for a second attempt. Ideally, a fast, free-wheeling powered reel winch is required for the deployment operation. This was considered too costly and too involved for inclusion at present, but would be needed for future multiple deployments.

The array operation was monitored as the dragging occurred. At one point there was a loss of DSL synchronization and this is where we stopped dragging. Synchronization was restored and the array operated normally. The array was at least partially straightened by this operation, but was not expected to be fully extended.

The successful deployment of arrays in water depths and currents representative of the area is a difficult operation. Among the problems arising are that the entire array hangs in the water column and drag, even in a 1 kt current, is large. This drag gives the deployment people the feeling that the array is on the seafloor and that they must pay it out. Communications between all members of the team is important. Typically, distance and noise levels preclude this from happening properly. The boat driver, the mate, the array handlers, and the navigator all need bullet proof, hands-free communications. The mate has to watch for safety and line handling etc., the driver needs to keep the vessel on track and making proper speed over ground, the handlers need to understand what is happening, but all orders (except safety and ship handling) need to come from the navigator who is constantly watching the position, speed over ground, and cable payout rate.

Array Recovery and Repair

The recovery of Array 1 was accomplished by using a “Mule.” The mule consists of a pair of trailer tires mounted side-by-side such that the side walls of the tires are almost touching. The rims are mounted on a common shaft that is driven by a chain reduction drive and a screw-drive with friction clutch. Lines or cables can be positioned between the tires and by simply

applying a downward pressure on the line or cable before and after the mule a variable degree of friction can be used to pull the line or cable. It is a simple matter to lift the line or cable out of the tires to reduce friction or completely free the line. The mule can be driven in either direction and stopped or started instantly. This pulling device is ideal for gently handling the array cable. It also works well with the anchor lines.

Figure 15. The navigator monitors the rate of cable lay and the vessel position.

Figure 16. The 'Mule' provides a convenient means of pulling on the cable without kinking it and can be quickly separated from the cable when necessary.

Using the mule we were able to easily and safely under-run the cables at will. Short pauses at the repeaters allowed us to walk the repeaters over the vessel and safely pass them off the stern.

Complete recovery of the cables requires that the cable be wound on to spools. Due to the length of cable involved some form of cable reel drive is required. A friction drive arrangement would be ideal as the loads are not large. This system is an alternative to the large reeler that was used in the recovery of the 9-km cable.

Localization of the underwater arrays

Array element localization (AEL) activities were conducted around Arrays 2 and 3. Array 1 failed before we were able to carry out AEL. This localization operation consists of the implosion of a number of light bulbs [1] under the influence of hydrostatic pressure at locations and depths known to some degree of certainty [2,3].

The light bulbs are broken by lowering them in a weighted support to a specific depth and releasing a "messenger" weight that slides down the supporting cable and impacts an anvil

that delivers a blow to the light bulb. The light bulb shatters with a resulting broadband “pop” that is recorded on the operating array.

The array hydrophone locations are then determined by a global non-linear optimization of the relative times of signal arrival on the array hydrophones constrained by the estimated uncertainties in all *a priori* location estimates. A significant degree of manual effort is required in this process and typically a day or two of effort is required to reach the final solution. The solution generally provides absolute hydrophone locations good to 10 m and relative hydrophone locations accurate to a fraction of a meter.

This localization procedure provides sufficient accuracy to allow high performance beamforming with the localized array.

The AEL results for Array 2 are shown in Fig. 17 and the results for Array 3 are shown in Fig. 18. Array 2 is shown to be deployed about 75 m east of the intended location. It is also a couple of metres further north than intended. The relative hydrophone location solutions exhibit a typical spacing error of about 5 cm indicating an AEL solution accurate to better than 10 cm in relative positioning. The array is very linear and fully extended.

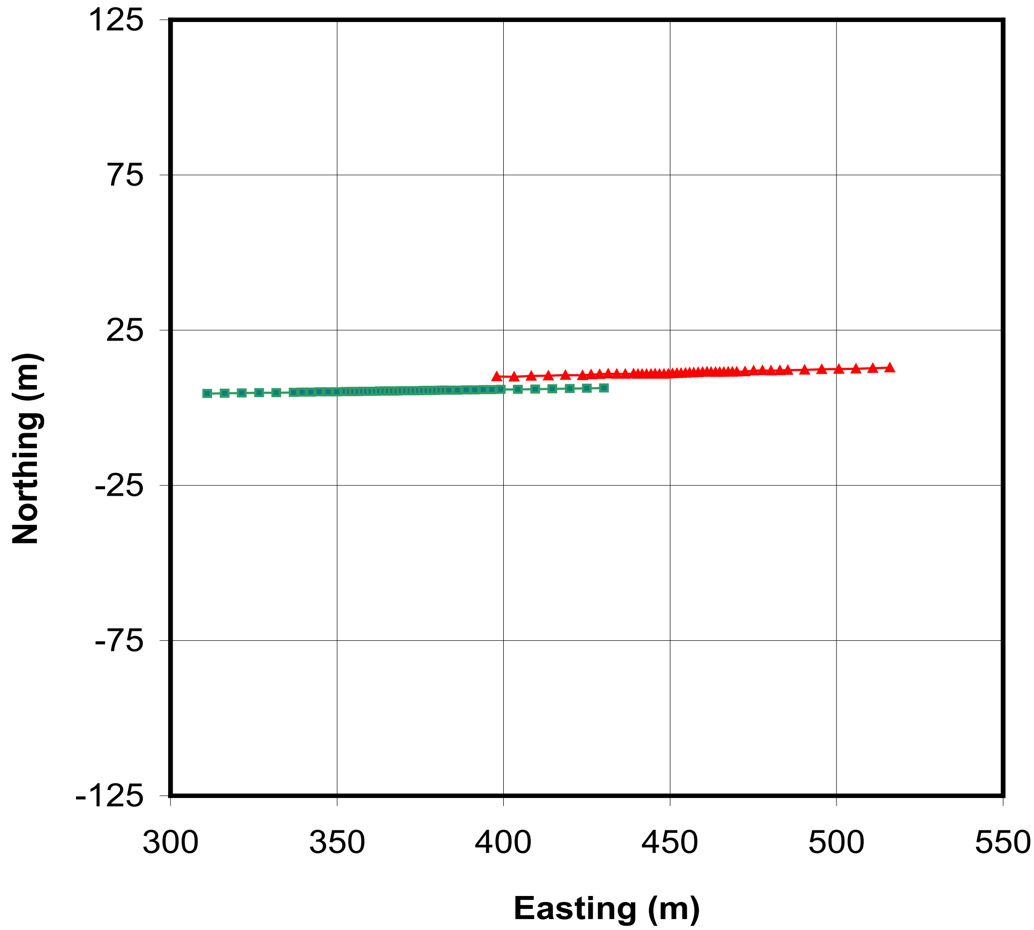

Figure 17. Array Element Localization results for Array 2. The initial array position estimate in green and the final result in red.

As expected the results for Array 3 show that the array is not fully extended. The latter two-thirds portion of the array is not fully spread. The array is about 50 m west and 40 m south of the initial estimate.

In both cases the AEL results are sufficient to allow advanced signal processing methods to be applied.

During this field trial we also collected data using the broadband noise of the deployment vessel to examine the performance of an enhanced localization procedure that may eventually eliminate the need for the use of light bulb implosions. Analysis of this data will not be completed for some time yet.

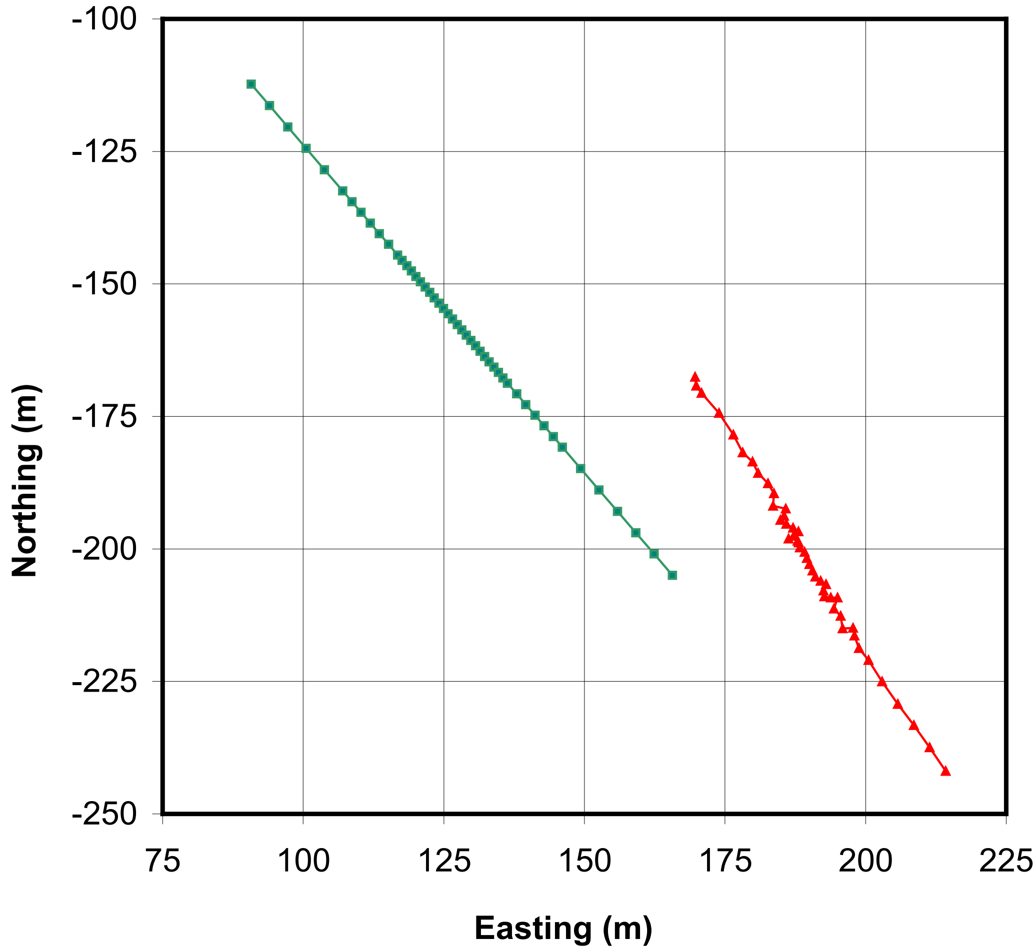

Figure 18. Array element localization results for Array 3. The original position estimate in green and the final result in red.

Clean out of foreshore cable protection pipe

The Gascoyne Inlet camp site has a long history of use by the fore-runners of DRDC. Decades ago, a pipe was drilled under the foreshore [4] so underwater cables could be protected from the ice floes during the winter months. We knew that three old cables were present in this foreshore pipe. Our plan was to grapple these cables, cut them if they ran any significant distance to sea and then use them to pull a cord through that would then be used to pull new cables into the pipe.

The old cables were located underwater using a small ROV driven from the beach. A float was attached to the largest cable and the cable was followed shoreward in an attempt to locate the underwater end of the pipe. The large cable, the two smaller cables, and the pink and blue heater cables were all found to be together, but, unfortunately, they and the end of the pipe are covered by an unknown amount of gravel.

We used the zodiac and raised and tugged on the cables, but were unable to expose the seaward end of the pipe.

The hot water drill was set up on the shore near the pipe opening. The drill was unable to prime itself and we used a simple hand pump to draw water into it. Once the pump was primed it was easily able to draw water from the sea. The drill was then used to heat the seawater and pump it through 45.7 m (150-ft) of ½" PEX hot water tubing.

The free end of the PEX tubing was pushed into the hole and we discovered that we could insert the tubing 7.3 m (24 ft) before encountering an obstruction. At this point water was pumped into the pipe and we allowed the pipe to fill and observed water overflowing and disappearing into the gravel. The heat was then turned on and the PEX tubing was repeatedly inserted and withdrawn a short distance from the pipe. Very soon we observed that the tube was advancing when the water was hot.

The rate of advance was variable, but at the end of an hour we had pushed an additional 16.75 m (55 feet) of tubing into the pipe. At this point we ran into problems with the pump motor and pump unit. In addition, the tide was receding beyond the reach of our intake hose. We ceased operations for the day and worked to replace the pump motor. We switched to a second pump unit as well, unfortunately both of them are in need repair or replacement as the shaft seals on both pumps are faulty.

The next day we resumed drilling and noted that we initially flushed a lot of ice sludge from the pipe. The PEX tubing quickly ran back in the pipe to the 24.4 m (80-foot) point. At this depth we encountered more resistance, but advanced at a rate similar to that achieved previously. Before long we had reached a point approximately 33.5 m (110 ft) in to the pipe. At this point, the hot water punched through the pipe and the overflow on the shore side of the pipe ceased. We continued flushing the pipe with hot water and inserted another 6.1 m (20-ft) of PEX tubing.

Some resistance was felt as the last of the tubing was fed into the pipe indicating the continued melting of ice. At 41.1 m (135 ft) into the pipe we decided to pull the tubing out and continued sending hot water through the pipe using only the larger diameter hot water drill tubes. This decision was made because we wanted to be sure that all of the ice above the lower end of the PEX tube had been melted and because a second PEX tube coupling would have to enter the pipe. The couplings are of larger diameter and cause increased resistance to the PEX being pushed into the pipe. There was concern that the couplings could separate and leave the pipe plugged with the PEX tube. In addition, the new pump motor was beginning to seriously overheat. It is possible that the long, small diameter tube was creating too great a load on the motor.

We continued to run hot water down the pipe for an extended time. During this interval we used the zodiac to pull on the cables from the seaward end. This was done in hopes that the gravel would fall free from the tube. Unfortunately, the cable was immobile. We then used a come-along to exert a considerable force on the cable from the land side. The pull stretched the cable slightly and tore the cable jacket, but the cable did not move.

Figure 19. Al operates the hot water drill, while others feed the PEX tubing into the pipe.

Figure 20. Val and Garry feed the PEX tubing into the pipe to melt the ice securing the cables.

It is clear that it is an easy matter to free the pipe of ice. The hot water drill technique is a workable method. Unfortunately, the cable is buried under a sufficient quantity of gravel to preclude easy removal. Divers will be needed to open the seaward end of the pipe. The two important points are that the pipe is intact and the melting method is relative easy to use.

Collection of sensor data on vessels of opportunity

The arrays successfully collected data on: a speed boat from Resolute (19.5 ft, 150 HP Honda), an Aurora, a twin otter aircraft, a freighter the *Camilla Desgagnes*, and two cruise ships the *Bremen* and the *Clipper Adventurer*.

Figure 21 shows the resulting sonagram generated with data from Array 2 as the *Bremen* passed the CPA (closest point of approach). Using a 300-m telephoto lens we were able to photograph the ship in poor light and mist conditions of early morning (Fig. 22). The ship was at a range of approximately 8 km when it was photographed.

After localizing the array we were able to beamform the array signals from the *Bremen* and produce the bearing time history and FRAZ (frequency azimuth) displays shown below (Fig. 23).

Automatic Identification System (AIS) information was recorded during the trial. The signals from the AIS allowed us to plot a track for the passing cruise ships and other vessels. The results shown in Fig. 24 are for the *Bremen*.

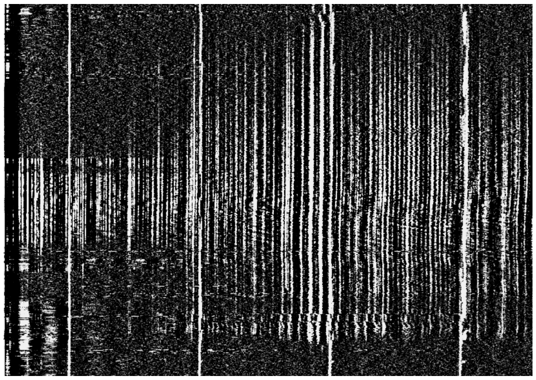

Figure 21. Sonagram generated at CPA for the Bremen *shown in Fig. 22.*

Figure 22. Photograph of the Bremen *taken in low light and mist at a range of 8 km.*

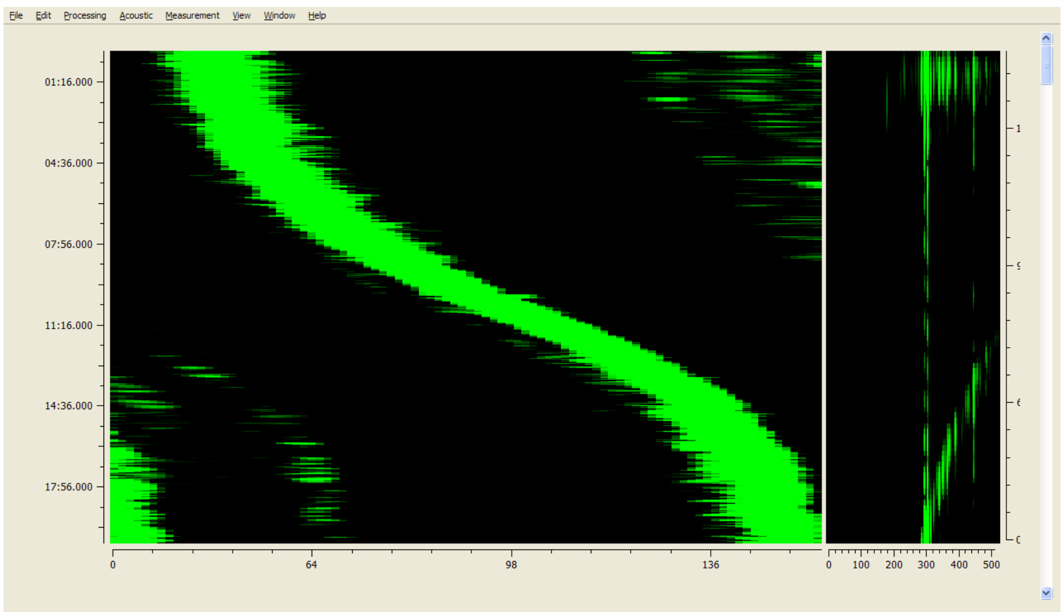

Figure 23. A bearing time history is shown on the left for the Bremen *shown in Fig. 22. The plot on the right shows a FRAZ display at a moment when the ship is near end-fire of the array.*

Other vessels in the area were also detected on the AIS after the underwater arrays had failed. These vessels included the *Apoise*, the *Akademik Loffe*, *MV Hanseatic*, *Lyubov Orlova*, *Glory of the Sea*, *CCGS Henry Larsen*, and return runs of the *Clipper Adventurer*.

Figure 25 is a composite of the AIS derived track of the *Clipper Adventurer* during several days when it transited through the area. On the eastward journey the vessel suddenly decided to revisit Beechey Island and then returned to the original track.

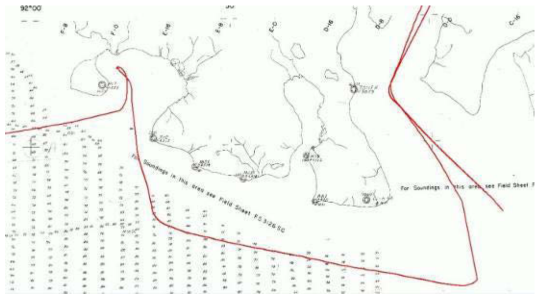

Figure 24. Cruise ship AIS derived track shows visits of the Bremen to Radstock Bay and Beechey Island.

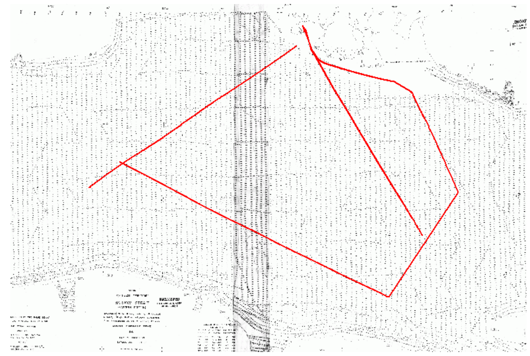

Figure 25. The Clipper Adventurer visited Beechey Island twice several days apart. The second visit appears to have been a sudden change in plans.

Collection of sensor data on co-operative vessels

The underwater arrays successfully collected data on the *CCGS Terry Fox* as it executed a cross-strait run and an along-strait run of 60-km length. AIS information was collected simultaneously with the underwater data and an independent GPS recorder captured the vessel track. In addition, bridge logs and navigation system records were obtained. We also collected data on the Fast Rescue Craft (FRC) RHIB and the SP Barge.

The *Terry Fox* is a loud vessel and is easily detected by acoustic means. The array was easily able to monitor the emissions from *Terry Fox* even when it was at its furthest distance away on the opposite side of the strait. The SP barge also generates a surprising loud signature and is easily tracked.

Figure 26. CCGS Terry Fox.

The FRC is a more interesting vessel. It has a very shallow draft and a ducted propeller. This combination provides a more difficult acoustic target where most of the acoustic signal is directed downwards. We have several recordings of the FRC and an analysis was conducted on one of these to demonstrate the ability to track and classify acoustic targets.

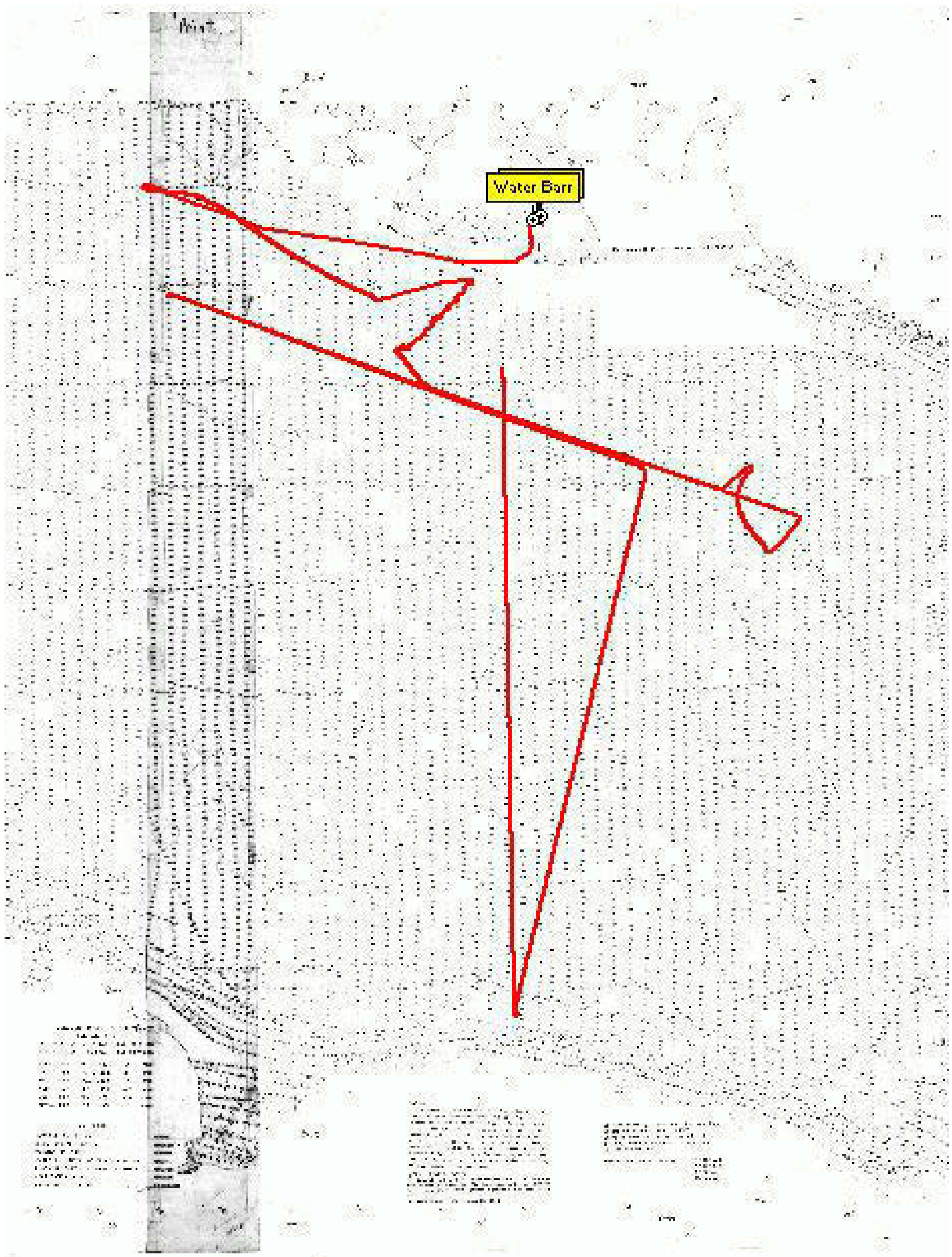

Figure 27. Terry Fox track during cross-strait and along-strait runs.

The tracking and classification technique applied was developed at DRDC by Ebbeson [5,6]. It is intended for short range application against nearby vessels. The technique is called Matched Correlation Processing (MCP). MCP requires a significant processing capability for real-time operation, but it is very versatile and can easily produce results on selected data in a

few minutes when run on a modest laptop computer. In the example shown here, the signals from only five hydrophones are used to localize the RHIB as it approaches the array from the east.

The potential target positions are searched systematically to find the best match to a modelled broadband correlation function. The example shown searches in 5-m steps in range and depth and 5º in angle. An ambiguity surface is created and the peak of the surface is taken as the most probable location of the noise source.

Figure 28 shows an ambiguity surface formed during the search for the target. In this case water depths to 120 m and ranges to 800 m are searched at 5 m intervals. The maximum value of the surface is denoted by the white colouration near top centre. This position almost exactly coincides with the actual source position denoted by the white cross-hairs. The target is clearly a surface vessel.

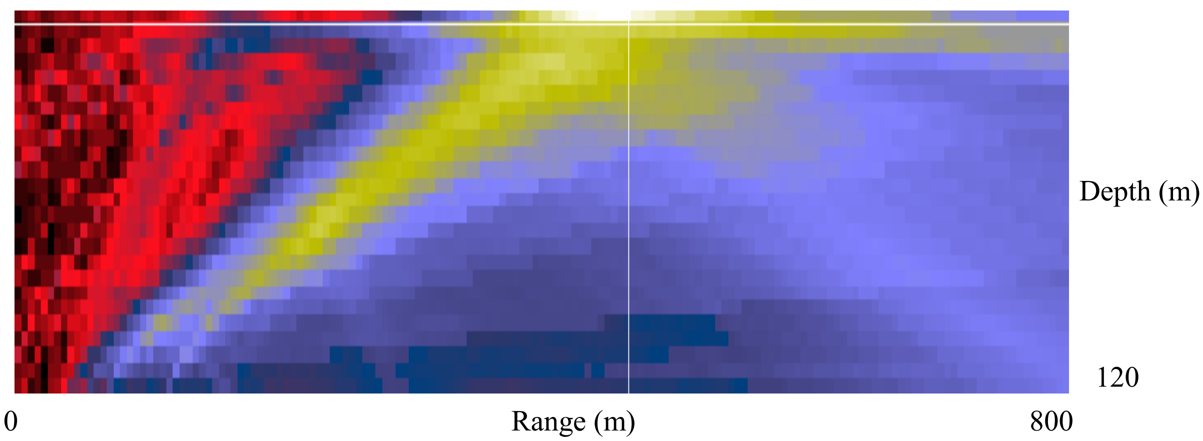

Figure 28. Matched Correlation Processing ambiguity surface showing a surface target near 450-m range.

Figure 29 shows a plan view of the vessel course and compares it to the known course and position. The RHIB is tracked with good accuracy at a range of 465 m. The ability to determine a course, position, speed, and depth allows a target classification to be made.

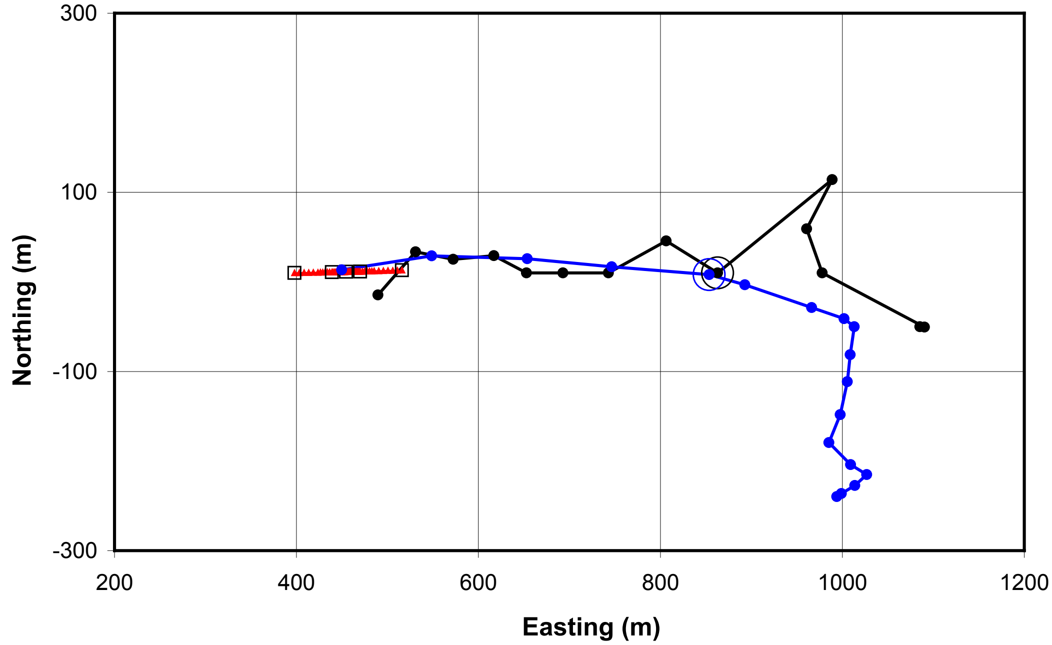

Figure 29. Comparison of the known RHIB track (blue) with the estimated track (black). The array of five hydrophones used in this example is denoted by the open black squares.

Collection of environmental data

Bathymetry information was recorded by the *Terry Fox* as she carried out the tracking runs. This information will be used to confirm the validity of the sounding data already held by DRDC.

Sound velocity profiles were collected at the completion of the *Terry Fox* run and also during the AEL measurements. The profiles measured in the vicinity of the arrays are shown in Figs 30 and 31. BIO also conducted a bathythermal survey for us from the inlet out into the strait. Together with historical data and coarse sampling from BIO's moored instruments we can build a useful picture of the thermal structure in the strait that will assist in propagation modelling.

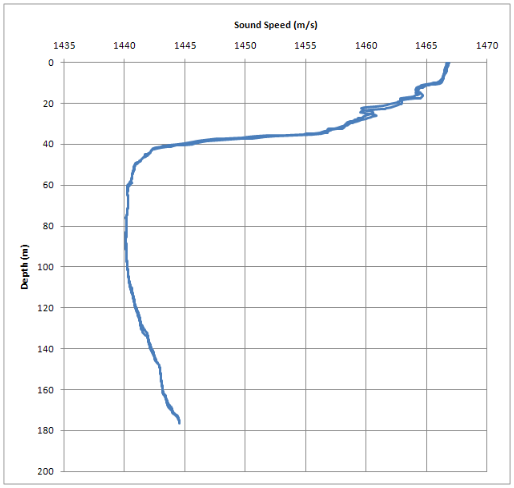

Figure 30. Sound velocity profile in the vicinity of Array 1.

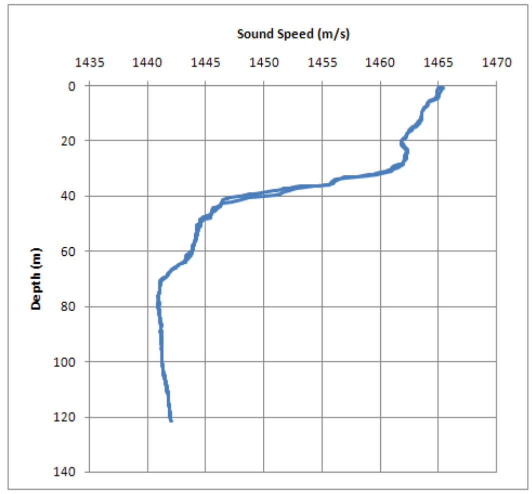

Figure 31. Sound velocity profile in the vicinity of Array 2.

Collection of ambient noise data

The arrays were operated for several days and at times the *Terry Fox* was either distant or drifting/anchored with main engines in the off state. This data allows estimates of the spectral levels of ambient noise in the strait during the summer months.

Figure 32 shows the ambient noise levels estimated at quiet intervals during the Propagation Loss experiment. The levels are short-term averages, but are believed to be representative of the noise levels in the area when there are no discrete noise sources present. There are however some increased levels at the higher frequencies that are probably due to the presence of *Terry Fox* and, possibly, other ice breakers and cruise ships that are operating in the region.

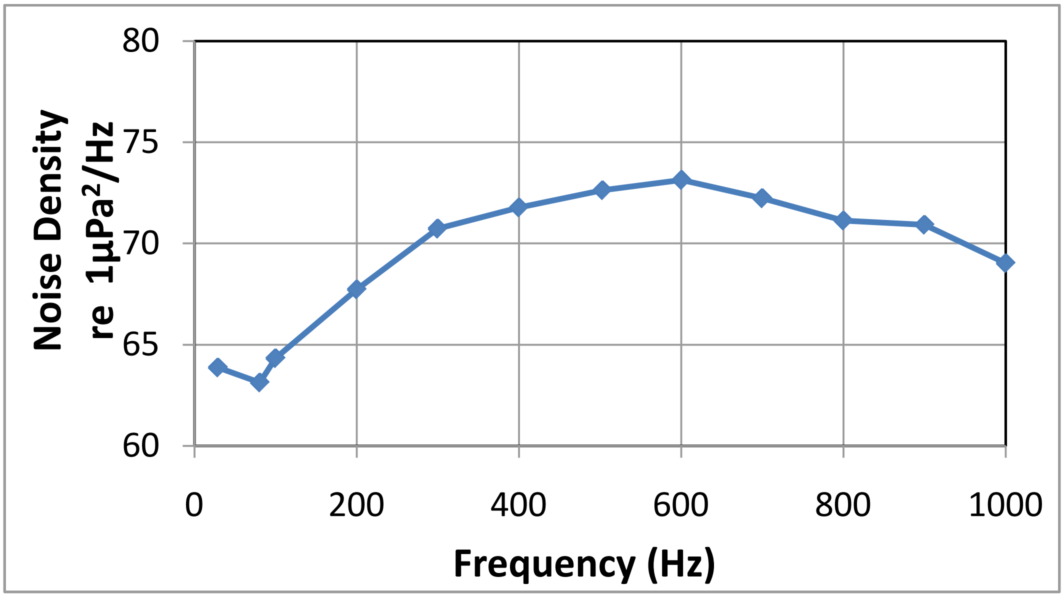

Figure 32. Short-term estimate of ambient noise at mid-day in August near Array 2.

Collection of transmission loss data

A short-range (10 km) propagation loss experiment was conducted using a battery-powered acoustic source. The source was moved to different locations, held almost stationary, and used to transmit two different tonal frequencies one-at-a-time. The frequencies chosen were 390 Hz and 590 Hz.

Data were recorded at each frequency and each source position for a nominal interval of four minutes. The recorded data were Fourier analyzed to provide an averaged spectrum level over the entire 4 minutes. These averaged spectrum levels were then used with the known source levels to determine the propagation losses that are summarized in Figs. 33 and 34.

At each site the projector was lowered on a rope and a Monarch depth logging instrument was attached to provide a measurement of the projector depth. Depths varied from 53 to 68 m at the eight stations. This change in depth from an initial value of 68 m to a final value of 53 meters was the result of difficulties with the connectors and electrical cables. The projector cable had to be changed for the last four stations resulting in a shallower depth. Unfortunately, this change in projector depth will preclude direct comparison of the measured losses with a single model prediction. It will still provide a valuable indication of the expected losses and help in building an effective geoacoustic model of the environment.

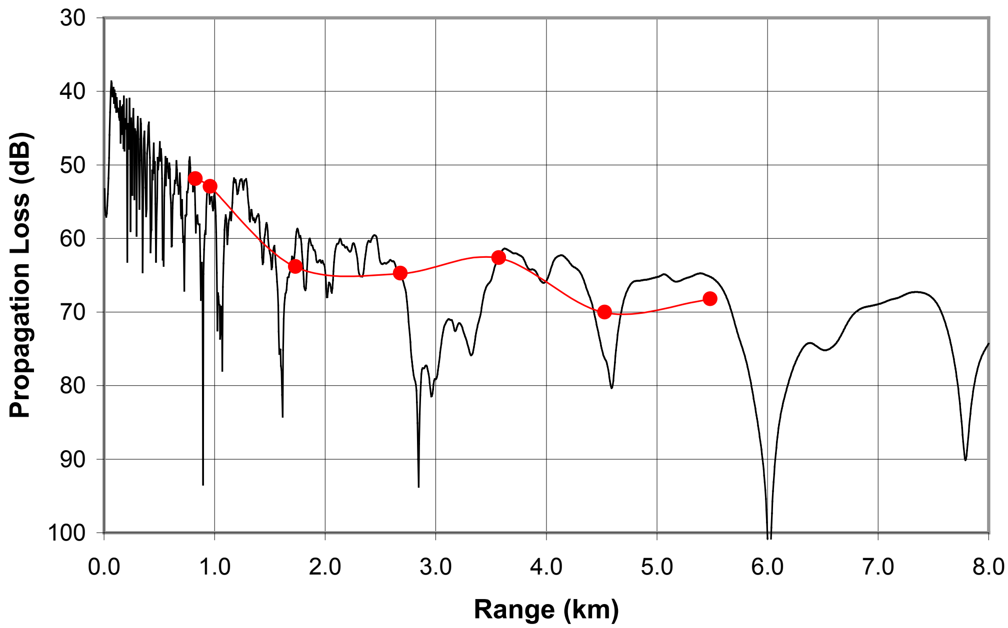

Figure 33. Measured propagation loss estimates (red) at 390 Hz in the vicinity of Array 2. Modelled propagation losses (black) determined with a flat-bottom model using PECan.

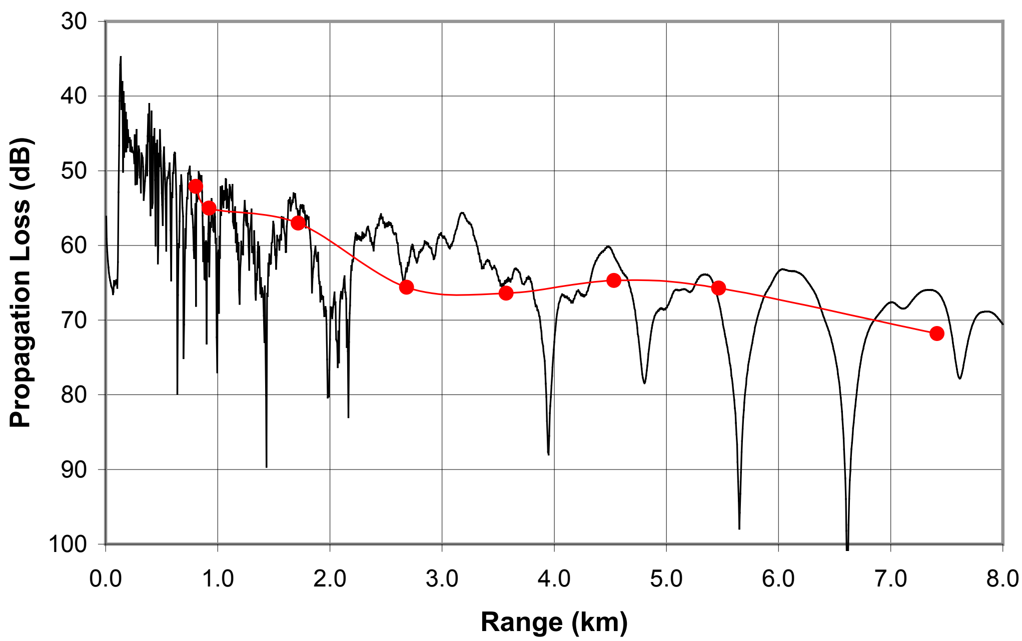

Figure 34. Measured propagation loss estimates (red) at 590 Hz in the vicinity of Array 2. Modelled propagation losses (black) determined with a flat-bottom model using PECan.

Establish and test satellite communication connectivity with the South

Unfortunately, the satellite communications system used last year was unavailable this time around. We did not know this until it was too late to make other plans. Some qualitative data were collected by employing a brief-cased sized BGAN satellite communications system. This system uses INMARSAT satellites and it was not initially known if it would work at this latitude.

We used the BGAN to transmit messages south over the Internet with great success. We had relatively good bandwidth as there were likely no other users in our sector. Unfortunately, the BGAN system can be expensive to use and we minimized operations as the costs can quickly build using this device, particularly in data-streaming mode.

Figure 35. Gord prepares a message to transmit south using the BGAN portable satellite system.

The only other satellite activity conducted was through the use of Iridium phones. We made quite extensive use of the phones as they were the primary means of communication between *Terry Fox* and the Camp, and between the Camp and Resolute. Iridium worked quite well, but there were many signal fades and dropouts that would be problematic for digital communications. A very clever modem scheme will be required to transmit any amount of C2 or image data with these phones.

Collect power usage data for support to long-term power plans

Power Usage

We used a power monitor to measure the power usage of the array system, the array server, and the primary client computer. Table 1 summarizes the measurements that were made.

The complete underwater acoustic system consists of the arrays, the telemetry/power cables, the array receivers, the array server, array power cross-over switch and an uninterruptible power supply. Various clients connect to the array server to provide system control and processing. At least one high-end PC is required on site as the primary client.

We were only able to operate one of the arrays at the time of the measurements and we did not stream data during measurements. Total power requirements would therefore rise by the power drain of a second Array Controller Receiver and array at the end of the line. Adding a total of an additional 100 W for the full system requirements is a reasonable estimate.

The uninterruptible power supply (UPS) was damaged in transit and was removed from the system for these measurements. The UPS would increase power demand slightly.

The main client processor power drain has been measured to be 192 W in full operation. The monitor, if required, draws an additional 38 W. The main server with all components active (one array off, one ACR off, no UPS, and no data streaming) requires 355 W. With the additional 100 W to allow for the missing elements, total system power is estimated to be 685 W.

Table 1. *Acoustic System Component Power Usage*

COMPONENT	VOLTAGE	CURRENT	POWER	VOLT-AMP	POWER FACTOR
Main Data Processing Client Computer DRDC 20615 In "OFF" state. Monitor attached and on, but powered separately.	126.1 126.4 126.5	0.082 A 0.090 A 0.113 A	5.4 W 5.5 5.6	11.5	0.46
Main Data Processing Client Computer DRDC 20615 In "ON" state. Monitor attached and on, powered separately.	125.0 125.4 126.5	1.339 1.36 1.76	124.3 126.1 165.0	166.7	0.75
Main Data Processing Client Computer DRDC 20615 In "ON" state. Monitor attached and on, powered separately. At completion of Liberkey CrystalMark Benchmark	124.9 125.5 126.5	1.339 1.35 2.01	123.9 126.2 192.0	167.5	0.75
NEC Multisync LCD1760NX monitor In sleep mode	124.9 126.3 126.5	0 0 1.184	0 0.8 0.9	0.8	1.0
NEC Multisync LCD1760NX monitor. Computer running benchmark	124.9 125.2 126.5	0 0.294 1.184	0 29.2 29.8	37.9	0.81
Main Server – off Array power – off Array receivers – off Cross-over switch active, both leads connected. Duraview Rack-mount monitor on. USB2 back up drive on.	124.7 126.0 126.2	0.549 0.585 3.22	31.3 31.4 63.4	70.9	0.44

Main Server – on. No change in other components.	124.4 125.2 126.2	0.541 1.81 3.22 (start)	30.9 170.4 248	207	0.79
Main Server – on. Both Sorensen DLM 300-2 turned on, output enabled. No change in other components.	123.5 124.1 126.2	0.541 (above) 2.84 3.67	30.9 259 261	338	0.76
Main Server – on. Both link power turned on. Active link with array 2, not with 1. ACR2 will not reliably stay online. No change in other components.	122.9 123.2 126.2	0.541 3.78 3.85	30.9 354 355	451	0.71

Solar Power

Data were also collected with a Kyocera KD135GX-LP 135 W solar panel to examine the usable power that can be generated in an Arctic environment. The experiments were conducted in August of 2009 when the sun was up 24-hours a day.

The solar panel was oriented to provide a normal surface to the solar rays at mid-day. As the sun moved around the sky, the panel fell into shadow. No attempt was made to re-orient the panel.

The panel was run into a series wire-wound resistor of approximately 1.1 Ohms and a series load consisting of three 100-W incandescent light bulbs wired in parallel. The voltage across both the resistor and light bulbs was logged to data files. The light bulb load was a poor match to the solar panel, but it was the best that was available in the field as this experiment was not pre-planned.

Figure 36 shows the time history of the power in Watts delivered by the solar panel over a period of almost 3.5 days. The load was a poor match to the solar panel and it is apparent that considerably more power could be drawn from an illuminated panel than we have recorded.

With generally clear weather for the most part, the panels had a very similar performance each day. The panels produce a fairly constant output level for 9-10 hours each day in our setup. With a better load match we would likely have seen more variation during the period of direct illumination. Power onset and decay is rapid. A circular array with 4 or more properly oriented panels should be capable of producing reasonably constant power levels throughout the duration of a clear day with sun well above the horizon.

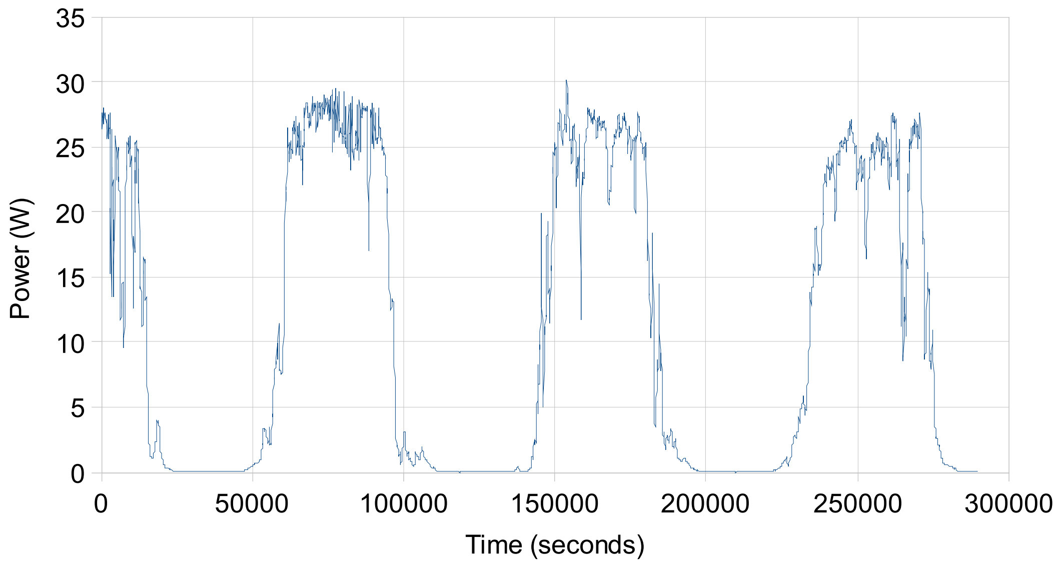

Figure 36. Solar panel output power versus time in seconds.

Improving arctic experience and training level for participants

This field trial and the prior camp setup trial were very effective at improving the experience and training levels of staff. These two trials were the first Arctic experiences for: Peraza, Hutt, O'Grady, and Grychowski, (also Baldin, setup trial only). They also significantly increased the experience levels for: Clark, Rouleau, Shepeta, and Pelavas. All participants benefited from the experience and exposure to new ideas and methods for many different tasks.

Significant areas of improvement include: array recovery and deployment, camping procedures, camp setup, animal awareness, toiletry considerations, waste handling, water handling, working with aircraft, travel in the wilderness, and safety considerations.

Despite all of the benefits of training, it must be recognized that the average age of the 12 field workers in the current group is 49.7 years! Ages ranged from 36 to 61. Only two participants were under 40! Only five are under 50 and in a month that will be just 4.

New, young people must be brought on line to replace and reduce the workload on what is a very old group.

Deployment of BIO UW cable

A 3-km underwater cable was deployed alongside our own cables as part of a collaboration with BIO. This cable will be used in the near future to connect to a telesonar modem and will hopefully provide near real-time connectivity with deployed oceanographic instrumentation in Barrow Strait. The BIO cable will be fed through the foreshore pipe once it has been opened.

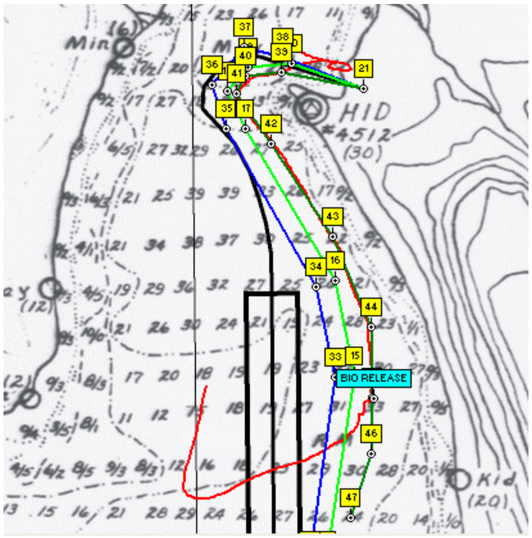

Figure 37. The cable paths for the DRDC array cables (blue and green) and the BIO cable (red).

Figure 38. This bundle is the end of the BIO cable. It was dumped in the water near Walrus Point for safekeeping over the winter.

Communications

The field activity has shown that we have not put enough effort into the communications at the camp. Our purchase of Iridium phones went a long way to improving the situation, but we must go considerably further in this area. It was apparent that potential participant safety and the conduct of the cable laying and collaborative experiments suffered from insufficiently reliable communications.

A number of steps must be undertaken to improve the communications and therefore the resulting safety of the participants and the quality of the work done.

Communications at camp

An immediate problem is the establishment of a proper communications centre at camp. At present, this is located in the very small and crowded kitchen area. This has been a good idea in the past because the kitchen is the most frequently occupied space. Unfortunately, people continuously turn the volume down on the main receiver used for the scheduled communications with Polar Continental Shelf Project (PCSP) in Resolute. This frequently resulted in the camp missing the scheduled communications sessions even when the kitchen was occupied. ***Observation shows that it is not sufficient to repeatedly tell people to leave the radio volume alone! The volume controls must be locked.***

Minimal camp crewing makes it impossible to dedicate one person to the communications task. That person is often away from camp, on the ship, or otherwise busy. ***An audible alarm system is required to alert participants to incoming calls from HF, Iridium, Marine Band, and walkie-talkie channels.***

It seems incredible, but we had a great deal of difficulty being available for the 0730 and 1900 scheduled radio calls with Resolute. This difficulty is due to a number of reasons, but primarily people were too busy or too tired. The lack of a regular daytime schedule for meals and activities along with 24-hour watches and continuous daylight also increased the difficulty. ***An automated timer is required to alert participants to scheduled communications.***

Re-establishing an Internet link is also of prime importance. Beyond the official need for this link to provide email, weather reports, and data flow south, with this link we can reduce the need for Iridium phone usage and improve personnel morale. It is an unfortunate fact that few people can participate in a 5-week trial without an improved linkage to family.

We did not have the need or opportunity to test a broadband wireless link capability during this field trial; however, this will be an absolute necessity if the above water sensors are manned by a separate camp.

Communications in the immediate area

A third Iridium phone is required. This phone should be dedicated to personal calls only. Doing this will ensure that the other two lines are free for official use. Many official Iridium calls could not be completed. Frequently, no one at camp answered the phone at all. Other times the line was busy and generally thought to be in use for a personal call. One Iridium

phone must remain as the main camp contact line, while the other phone travels to ships, boats, ATV's, aircraft as required during the trial.

A significant problem with the Iridium phones occurred about two-thirds of the way through the trial. This problem prevented anyone from outside calling in to our phones. Our own phones were no longer able to call each other. We were only able to call out on the phones. After several sessions with the user manual, the Iridium help line was called. We waited for 19 minutes for a service representative, only to eventually be told that their offices were closed on the weekends.

Figure 39. Garry and Dan set up an Iridium phone and anxiously await the conversation.

A walkie-talkie and marine band repeater must be included in the gear. The region is very hilly and direct line of sight cannot be relied upon. The walkie-talkie repeater is an absolute requirement for safety. The marine band repeater is necessary to allow coordination between the array controllers and the people working in the boats.

An investment needs to be made to upgrade our existing radio gear, and a serious effort is required to maintain this gear to be used on field trials. The Icom radios are in poor condition. Only a couple of them will hold any sort of battery charge. Most are damaged (broken antennae, cracked cases), few chargers are available, and no spare batteries exist. Proper care and attention must be given to the radios. Headsets must also be provided as participants are often in high noise conditions and cannot hear the radio transmissions otherwise.

Communications to Resolute

The primary communications link to Resolute is through the twice daily scheduled HF calls. It has already been described how a timer and alarm are required to alert participants to calls from Resolute.

It would also make sense to set up a full-length properly masted and oriented HF antenna at the camp. We have been making do with an un-tuned piece of wire.

Iridium phones provide a secondary link with Resolute and the primary link to the LOGO in Resolute. Calls both ways have been difficult due to the impossibility of maintaining a constant phone watch or even constant network registration. (Iridium is not like the well known cell phone!)

Communications to ships and aircraft

We have a single marine band radio, which to date has also resided in the kitchen. This radio needs a repeater to allow communications to vessels operating in the strait. We did a lot of relayed communications through a vessel in sight of both ends of the link. In camp repeaters should include access points in the Science Hut and Comms Centre.

Aircraft from PCSP use the same HF communications frequency that is used for the daily scheduled calls. It would be convenient to have a list of call signs.

Underwater Sensors

The intention of the field trial was to leave behind two working underwater array systems that could be returned to operations by manning the Gascoyne Inlet camp at any point over the next few years. Unfortunately this goal was not achieved. All three of the arrays failed after a few days of operations. The failure mechanism has been shown to be related to a problem with adhesives and resins, which allowed water to penetrate to the electronics.

Water was able to seep between the PVC casing and nitrile boot. We had foreseen this as a potential issue, but firmly believed that even if the boot was cut or torn it would not be a huge problem as the cavity behind the boot was filled with an acoustic gel resin that would block the water penetration. It turns out that the gel does not block water penetration. In fact, the water was able to flow down almost every surface between the gel and other objects such as wires, hydrophones, and PVC components.

A third problem occurred at the interface between components and the hard resin that encased all electronic components. Water was able to seep into the resin and finally achieve access to the printed circuit board by following the interface between the hydrophone boot and the resin. The ‘hard’ resin can be dented with a fingernail. This degree of hardness was not expected.

A forensic analysis of the array failures will be done in the near future.

During the period of operation we were able to collect a significant quantity of data and were able to show that we can detect targets at considerable ranges, even with single hydrophone processing. We also showed that the underwater arrays can detect underwater, surface, and above surface targets. We have also shown that with the assistance of divers we can make use of the foreshore pipe and create a long term monitoring station.

Next Steps

NW Project overall

The Northern Watch project is currently undergoing an extensive review. The results of this review will alter the overall project objectives, schedules, and budget. Meetings for this review are scheduled to begin in September 2009 and will be followed by a Senior Review Board meeting to affirm directions.

Underwater acoustic sensors

The underwater acoustic sensors activity has proven the application of the devices to the detection of underwater, surface, and above surface acoustic sources. Unfortunately, problems have occurred during the past two years that have prevented this aspect of the project from progressing as quickly as desired.

In 2008, weather conditions, ice, limited ship time, and lack of proper equipment prevented the successful deployment of the arrays. Had the arrays been deployed they would have failed due to water leakage into the hydrophones.

In 2009 all conditions were improved. We had better weather, a longer available period of ship time, an extra array, acoustic releases for improved deployment pauses, and two mechanical cable lifting devices to ease the job of deployment or array recovery. Unfortunately, all three arrays were built in the same manner and unexpectedly developed water leaks that eventually caused them to stop operating.

The last two field trials have taught us a great deal. They have allowed us to prepare better recovery and deployment gear as well as improve deployment and recovery techniques. We have shown how long the mechanical parts of the array backbone cable will last. We have shown that the array has the necessary capabilities for the job. We have shown that we can localize the deployed arrays with sufficient accuracy to allow beamforming and other more sophisticated signal processing techniques to be used. We have also shown that the foreshore pipe appears to be intact and that the ice in it can be melted and that it can be re-used to protect the cables at the water-land interface.

What we have to do next is refine the design and materials used in the construction of the arrays to ensure that they remain waterproof for many years. We also have to address the mechanical lifetime of the array backbone cable. Corrosion is much more significant than anticipated and it will be necessary to either use anodic protection or redesign the cages so that plastics and /or ceramics are used. This change in cage design will ensure a long array cable lifetime and allow the cable to be recovered after a longer interval of time.

Because corrosion has been so significant we must also prepare for the replacement of the repeater nodes currently deployed. The repeater nodes constructed in 2009 were originally an all plastic (PVC) canister. However, during testing of these canisters the lids were observed to fail with pressure prematurely. It is believed that these failures are due to an inconsistency in the PVC plastic properties. In order to maintain the delivery schedule, it was necessary to replace the canister lids with new lids made of anodized aluminium. There is a risk of a reduced lifetime of the lids if the hard anodization fails.

While the arrays were tested prior to delivery, we must increase the amount of testing conducted. First, the testing must be done on individual new prototype array nodes. This testing must consist of detailed examination of the node's integrity and survival under various stresses. We need to test the integrity of glue joints after aging. We need to look at the survival of the nodes under pressure, temperature, and tension. A complete review of the casing materials and resins must be undertaken. The mutual compatibility of the materials must be considered. The placement of components and the quality control during construction must all be addressed.

Once an improved node design has been completed an array must be constructed for further testing. This array need not have all 48 hydrophone elements, but it should have a sufficient number of elements to ensure enough opportunities to observe probable failures. This new array should then be pressure tested for an extended period of time. Assuming a successful pressure test result, the array should then be deployed in as realistic a manner as possible to ensure that realistic deployment stresses and pressures are realized. The array should then be operated for an extended interval. Following an assumed successful deployment period the array should then be recovered and re-tested in the pressure tank at full rated pressures for an extended period.

Once a prototype has passed this rigorous testing, then additional arrays should be built and pressure tested. The arrays must be built to the same standards as the test prototypes. The arrays that successfully pass this testing will then be ready for deployment in the Northern Watch project.

Finally, the gear used for deployment and recovery needs to be reviewed and one of the two options (reeler or mule) selected. A purpose built deployment/recovery device needs to be constructed to properly control and speed up the operations.

General Activities

This section lists and prioritizes a number of item or additions, generally to the camp itself that were noted missing, incomplete, or in insufficient supply.

Table 2. Next Steps –general items.

ITEM	DESCRIPTION	REASON	PRIORITY	DIFFICULTY
			A – high, B –Med, C - Low	***1 – Hard, 2 – moderate, 3 - easy***
1	New LCD projector	Briefings, Morale	B	3
2	Bear scare pistols, charges and 22 blanks to replace the pen style bangers	Health & Safety	A	1
3	Simple air exchanger vents for buildings. Some in camp now.	Health & Safety	B	3
4	Electric fans to circulate air and heat	Health & Safety	A	3

	in buildings			
5	Power packs to run fans on the heating stoves 12Vdc	Health & Safety	B	3
6	Clear box / packing tape	Practical	B	3
	Garbage bag corral	Health & Safety	A	3
7	Larger quantity of biseal tape	Practical	B	3
8	Electrically driven, 12 Vdc, self-priming water pump for the water line	Practical, Health & Safety	B	2
9	Modify Hot Water drill with self-priming water pump and long hoses. Tested for continuous operation in warm weather and with resistive load.	Practical	B	1
10	• Bear fence upgrades: 1. Three gates, 2. All required bolts and screws, 3. Ensure enough wires, 4. Secondary tone for lowest wire, 5. Emergency tone manually triggered, 6. Battery monitor, 7. Break location detector and display.	Health & Safety	• A A A A A B B	• 2 3 3 2 2 3 1
11	Small rubber bands for banana plugs on bear fence	Practical	C	3
12	Cable entry ports on buildings to keep water and drafts out.	Practical, Health & Safety	B	3
13	Long and short, powered drain snakes	Practical	B	3
	New electrical panels for G5 and G6	Health & Safety	A	3
14	RV anti-freeze 10 gal.	Practical	A	2
15	Dish washer	Health & Safety	B	2
16	Washing machine	Health & Safety	B	2

17	Track shelving	Practical	C	3
18	Low-frequency speaker and amplifier	Operational	A	3
19	Solar panel test platform	Operational	B	2
20	repeater system power source (solar & battery)	Operational	A	2
21	Wind turbine mast and test system	Operational	B	2
22	New Nunavut and Canada Flags	Operational	A	3
23	Long fish tape	Practical	B	3
24	Conduit and bender	Health & Safety	A	3
25	Electric wire staples & conduit holders	Health & Safety	A	3
26	Generator cross-over system. Consider elaborate system to allow wind and solar backup through intermediate battery stage with 5 kW invertors.	Operational, Health & Safety	A	1
27	Electric plugs (male, female) 15, 20, 30 A polarized and unpolarized	Practical	A	3
28	Electronics spares and breadboarding supplies	Practical	B	3
29	Large power distribution box for main breaker box and revised electrical layout plan.	Health & Safety, Operational	A	1
30	A lot more paint (Grey, White, Red, Blue), metal primer, exterior primer, brushes, trays, rollers	Practical	B	2
31	Install outdoor taps for both hot and cold water and bring a long garden hose. Will allow filling wash	Operational, Health & Safety	A	3

	buckets, washing boots, washing BBQ, etc.			
32	New brooms and mops	Operational	B	3
33	Install Bosch water heater on kitchen water supply line directly. No hot water in kitchen when shower(s) running. Pressure is ok.	Operational	A	2
34	Groom road to airport	Operational	C	1
35	Consider flooring covering for some buildings. Science hut floor is breaking up quite badly.	Operational	C	2
37	Fuel berm for airport	Operational	A	1
38	New berm water pump.	Operational	A	3
39	Permanent covers for berms to keep water out.	Operational	B	1
40	Enlarge kitchen and include eating area	Operational, Health & Safety	A	1
41	New full size HF antenna with masts etc.	Operational, Health & Safety	A	2
42	New MB and VHF repeater station, new walkie talkies, earbuds, call alert system. Use voice modulation detector or ring-tone detector.	Operational, Health & Safety	A	1
43	Reading lights for bunks. Subdued directed lighting	Health & Safety	C	3
44	CGFI outlets in showers to allow vacuum cleaner to be plugged in.	Operational	A	3
45	New drills or additional batteries as the nicad packs will be frozen over winter.	Operational	A	3

46	Install female urinal	Health & Safety	A	2
47	Replace ATCO with 1 private bunk for cook and separate 2-person cabin for females	Health & Safety, Operational	A	1
48	Install short hoses in showers to facilitate cleaning.	Operational	A	3
49	All new POOP bags. Despite their so called two-year shelf life, similar bags broke at home after 2 months of storage.	Health & Safety	A	3
50	Generator shed requires major refurbishment to support dual gen sets and new distribution boxes	Health & Safety, Operational	A	2
51	DSL modem failure rates are high. Need to expand conditioning and testing of these units	Operational	A	3
52	Purpose built recovery and Deployment hardware (mule and driven cable reels)	Operational	A	2
53	Powered winch for emergency array recoveries during deployments	Operational	A	1
54	Deployment team (Boat skipper, Mate, Navigator, Chief Handler) hands-free communications system	Operational, safety	A	3
55	Establish modified procedure for human waste bucket. Large garbage bag in bucket first. Hold in place with large rubber band. Decomposable bag in bucket second. Hold in place with rubber band. In the event of a bag break, permanent outer bag can be removed and burnt. Eliminates	Health & Safety	A	3

	messy clean up.			
56	Wheelbarrow is needed for use around camp.	Practical	B	3
57	At least 10, 20 L (five-gallon) buckets are required for use around camp.	Practical	B	3

Figure 40. Flags fly in the wind at the Gascoyne Inlet Camp.

References

1. G. J. Heard, M. McDonald, N. R. Chapman, and L. Jaschke, ‘‘Underwater light bulb implosions: A useful acoustic source,’’ Proceedings MTS/IEEE Oceans 97, 1997, Vol. 2, pp. 755–762.
2. S.E. Dosso, N.E.B. Collison, G.J. Heard, and R.I. Verrall, “Experimental validation of regularized array element localization.” J. Acoust. Soc. Am. **115** (5), Pt. 1, May 2004.
3. G.R. Ebbeson, G.J. Heard, F. Desharnais, M.N.R. Matthews and S.E. Dosso, “Array Element Localization of a Rapidly Deployable System of Sensors”, Unclassified, DRDC Atlantic TM 2007-009, August 2007.
4. J. M. Thorleifson and D. G. Baade, “A Promising Approach for Taking Cables for Underwater Acoustic Installations Through the Shoreline (U)”, Confidential, DREP Technical Memorandum 86/5, February 1986.
5. G.R. Ebbeson and C.G. Greene, “Broadband target localization using the Canadian RDS-4 array”, Proceedings of TTCP MAR TP-9 RDS Workshop, 26-28 April 2004.
6. M.R. Matthews, G.R. Ebbeson, G.J. Heard and F. Desharnais, “Broadband Target Localization in Very Shallow Water”, Unclassified, DRDC Atlantic TM 2004-178, May 2005.

Annex A. Camp Maps

This annex provides a pair of maps that were created by using a hand-held GPS and walking along the various features while recording a track. The corner of each building was marked and positions were adjusted to fit with measured and known distances.

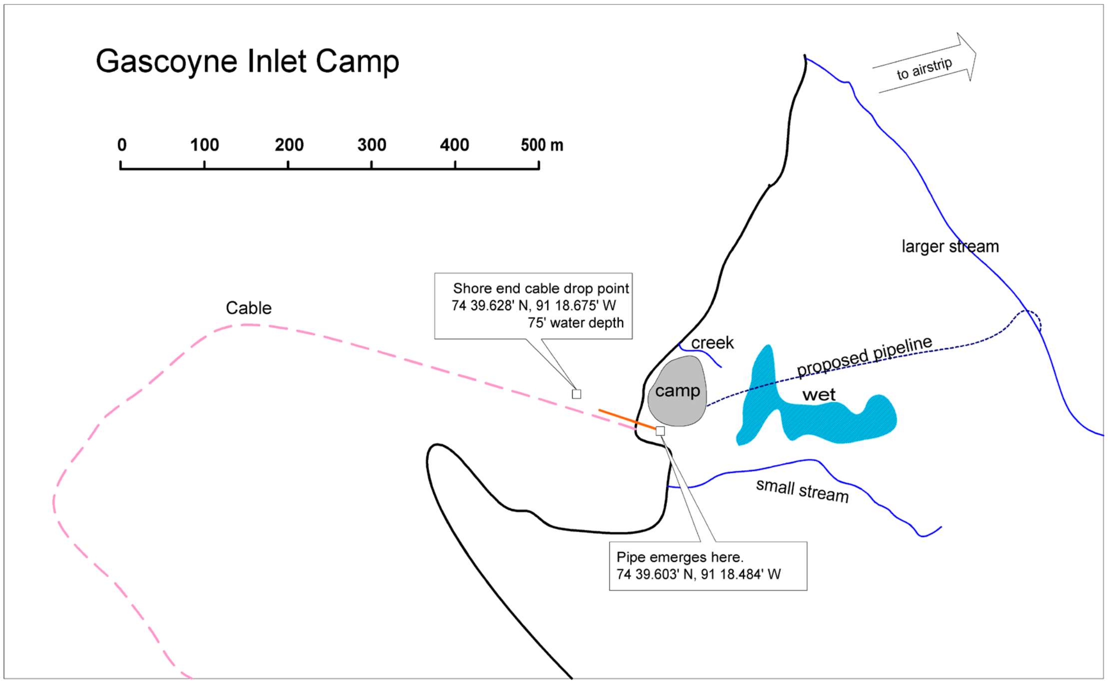

Figure A1. General camp area from a GPS survey conducted in summer 2008.

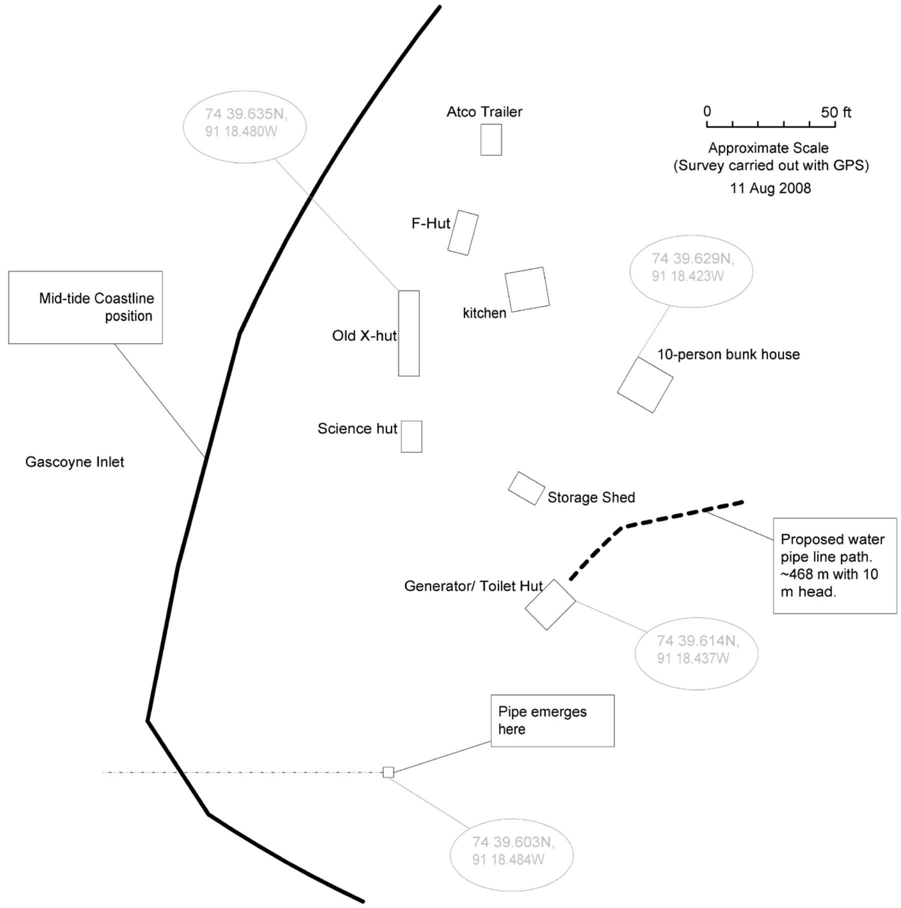

Figure A2. Map of the camp from GPS and tape coordinates surveyed during summer 2008.

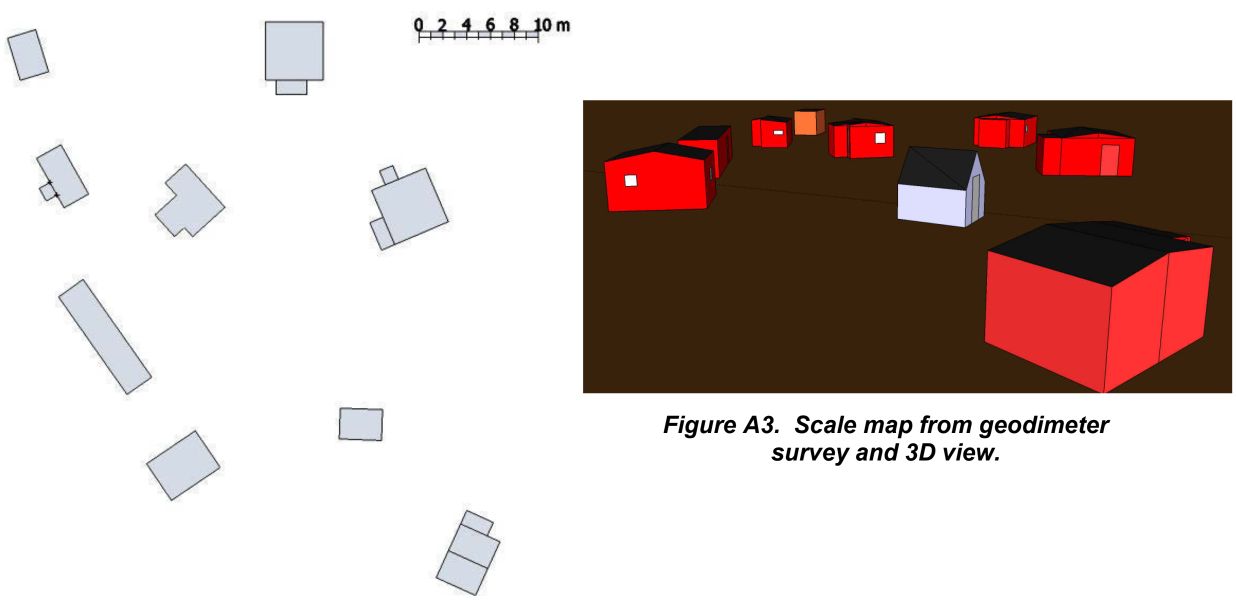

Figure A3. Scale map from geodimeter survey and 3D view.

Annex B. Building Drawings

This annex provides dimensioned line drawings of each of the camp structures. Each building diagram shows the location of circuit breaker boxes, lights, electrical sockets, switches, and heating stoves (fireplaces). In addition, the arrangement of doors, windows, and walls are shown.

- Electrical Symbols:
  - 0 Light Bulb
  - # Electrical Socket
  - $ Switch
- Dimensions are in Meters

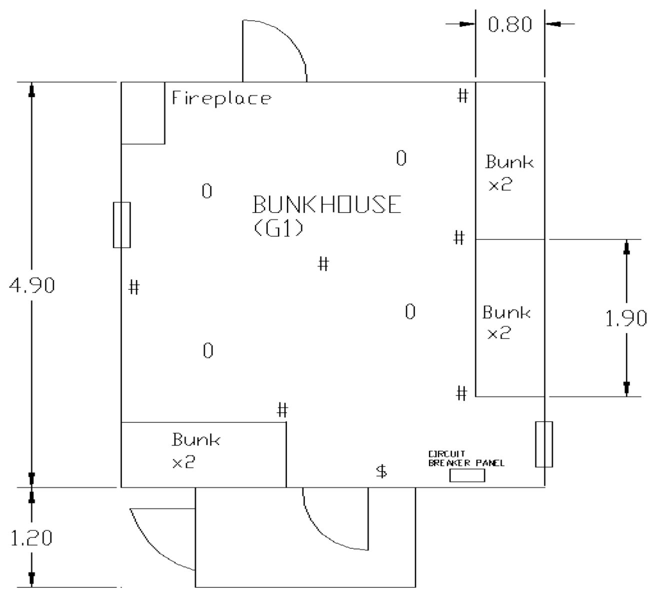

Figure B1. Bunkhouse Building G1.

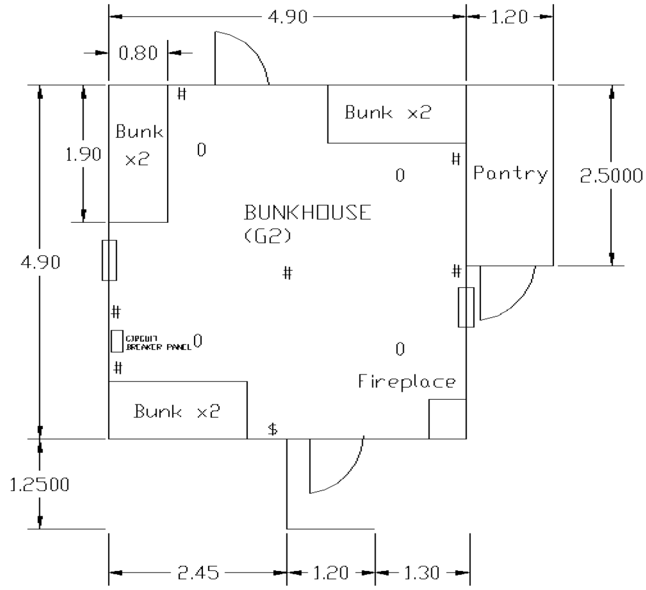

Figure B2. Bunkhouse Building G2.

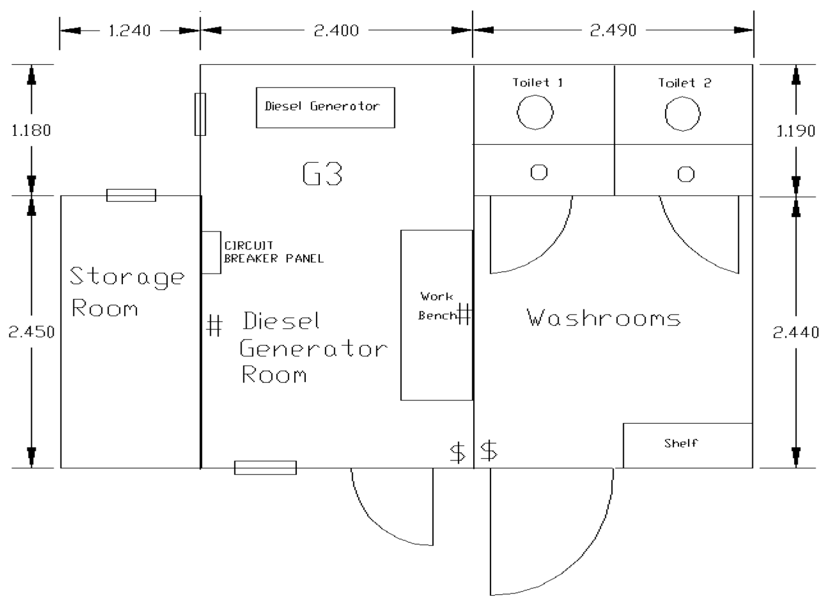

Figure B3. Generator and Toilets Building G3.

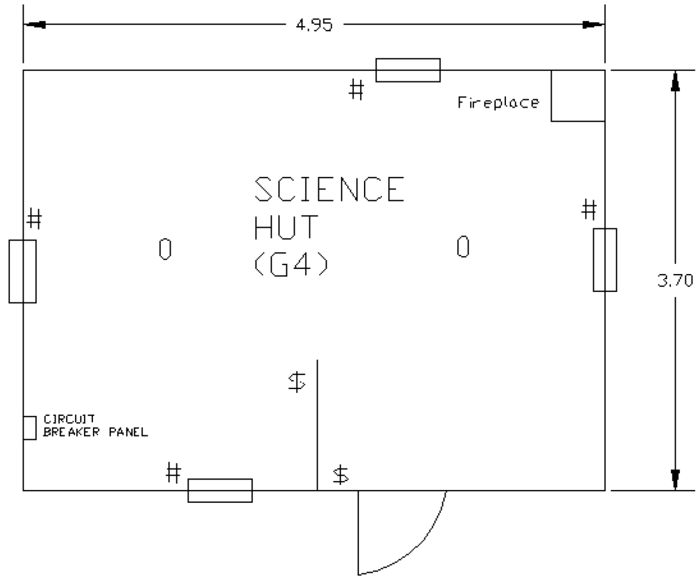

Figure B4. Science Hut Building G4.

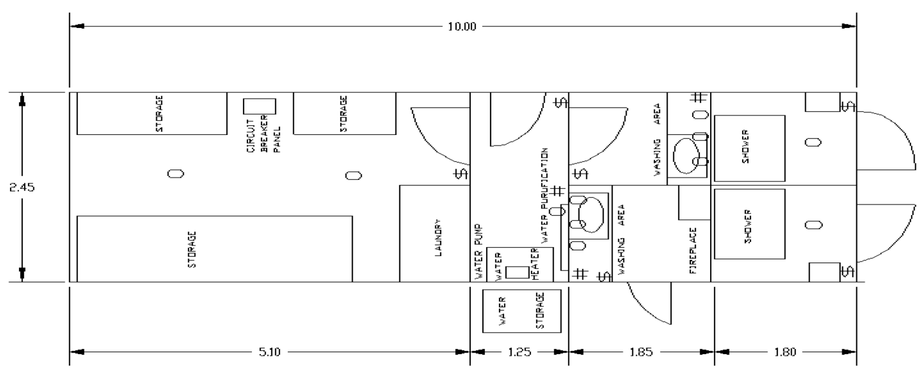

Figure B5. The old X-Hut Building G5.

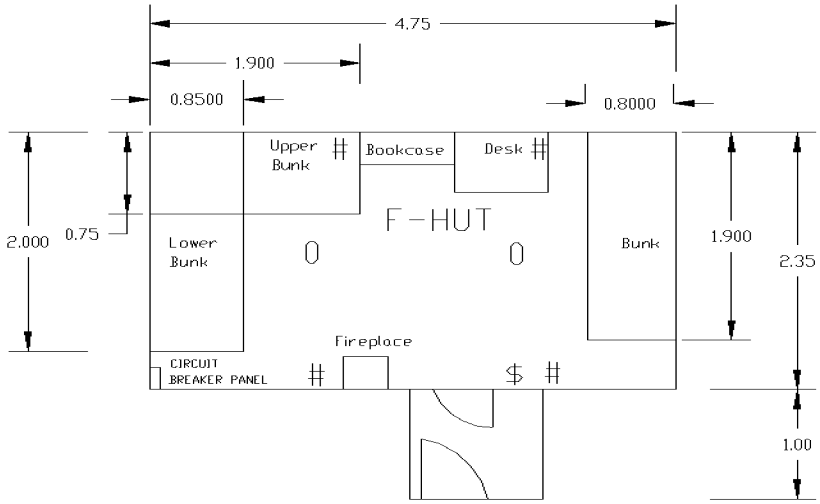

Figure B6. The old F-Hut Building G6.

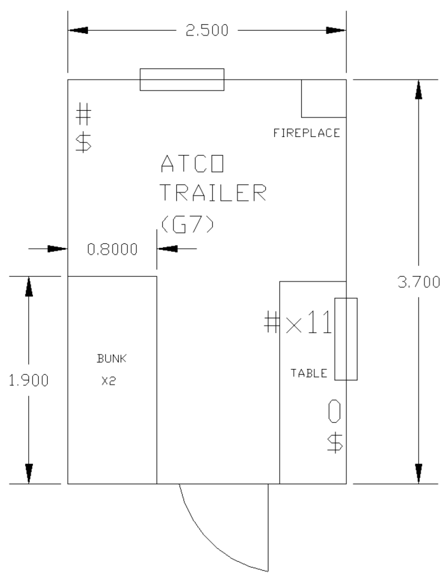

Figure B7. Atco Trailer Building G7.

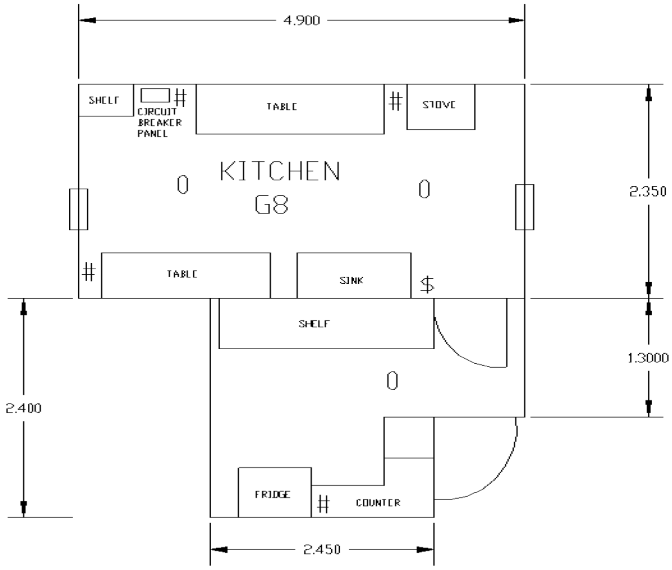

Figure B8. Kitchen Building G8.

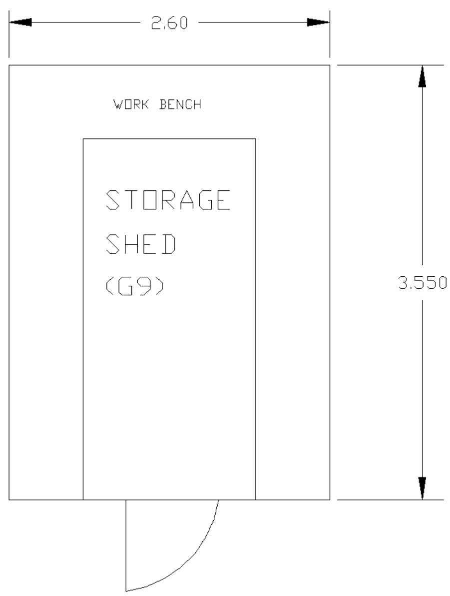

Figure B9. Storage Shed Building G9.

This page intentionally left blank.

Annex C. Building Photographs

This annex provides photographs of each building in the camp. One or more external views of each building are provided followed by one or more internal views.

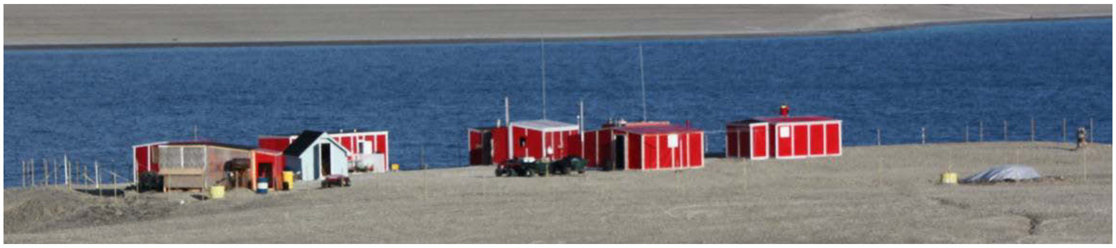

Figure C1. View of the Gascoyne Inlet Camp just prior to departure. View is facing toward the northwest.

Figure C2. Blockhouse G1 view facing NNE.

Figure C3. Interior view of Blockhouse G1.

Figure C4. Interior view of Blockhouse G1.

Figure C5. Blockhouse G2, view facing south.

Figure C6. Blockhouse G2, view facing north.

Figure C7. Interior view of Blockhouse G2.

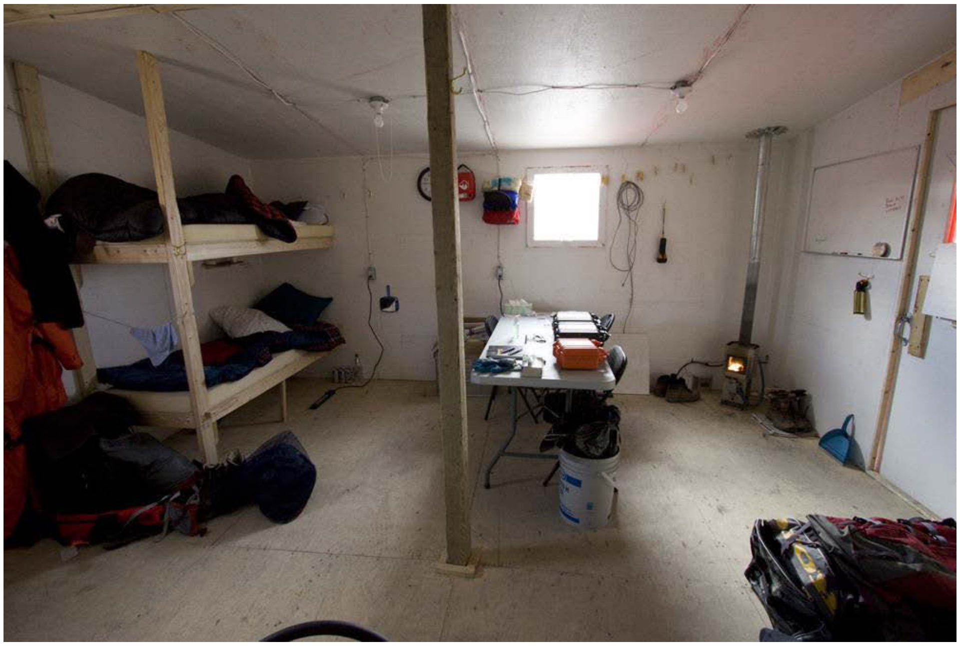

Figure C8. Interior view of Blockhouse G2.

Figure C9. Exterior view of Generator/Toilet Shed Building G3.

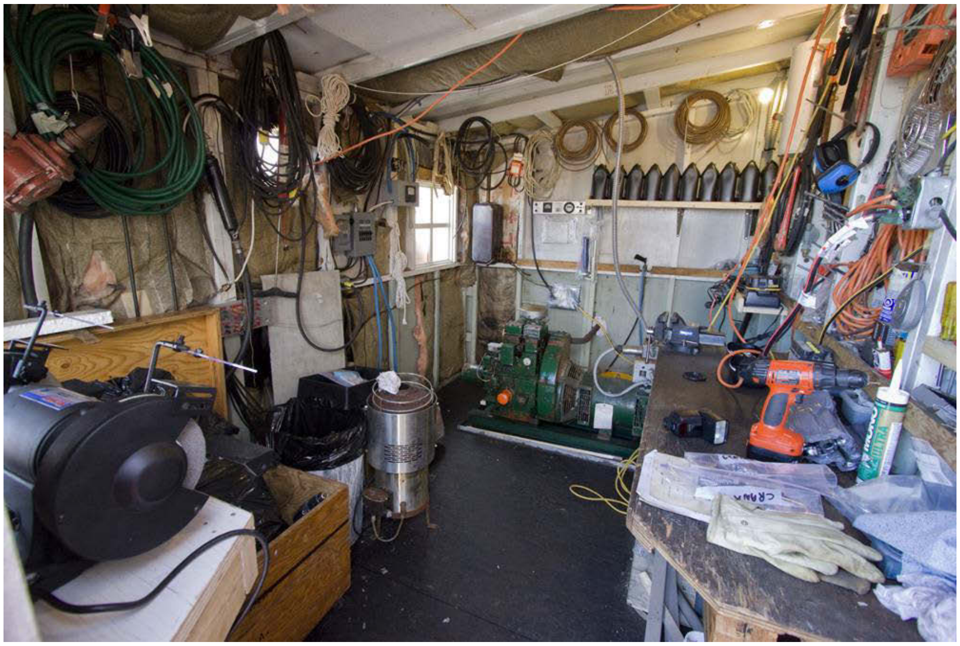

Figure C10. Interior view of Generator Shed G3.

Figure C11. Interior view of toilet side of shed G3. Toilet cubicles are located at rear.

Figure C12. Interior view of one toilet, G3.

Figure C13. Exterior view of Science Hut, G4.

Figure C14. Interior view of Science Hut, G4.

Figure C15. Interior view of Science Hut, G4.

Figure C16. Interior view of Science Hut, G4.

Figure C17. Exterior view of Storage/Wash Hut, G5.

Figure C18. Exterior view of Storage/Wash Hut, G5.

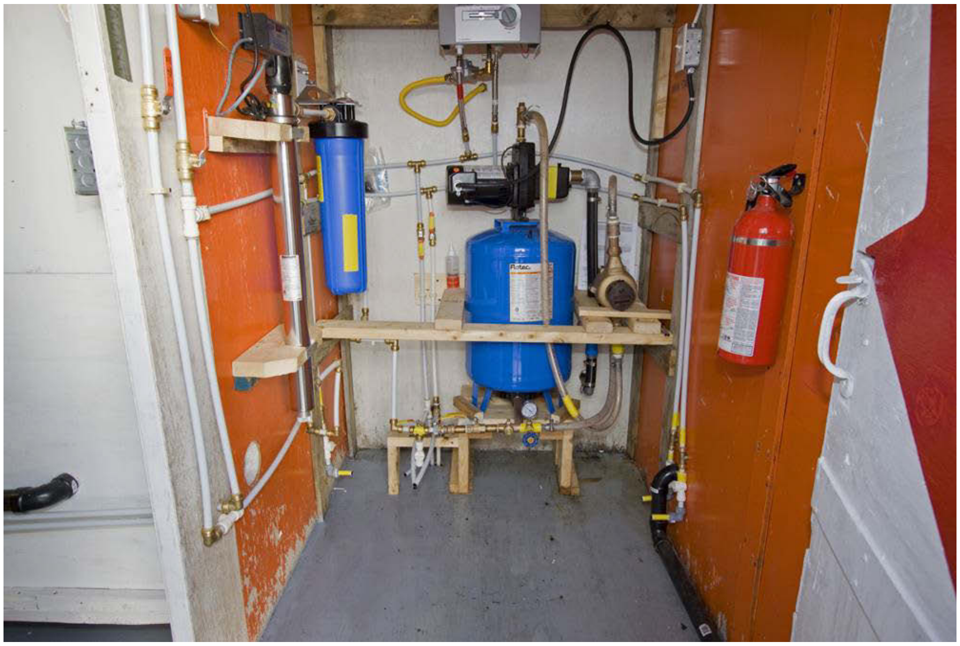

Figure C19. Interior view of Storage/Wash Hut, G5.

Figure C20. Interior view of Storage/Wash Hut, G5.

Figure C21. Interior view of Storage/Wash Hut, G5.

Figure C22. Exterior view of Old F-Hut, G6.

Figure C23. Interior view of Old F-Hut, G6.

Figure C24. Exterior view of Atco Trailer, G7.

Figure C25. Interior view of Atco Trailer, G7.

Figure C26. Exterior view of kitchen, G8.

Figure C27. Exterior view of kitchen, G8.

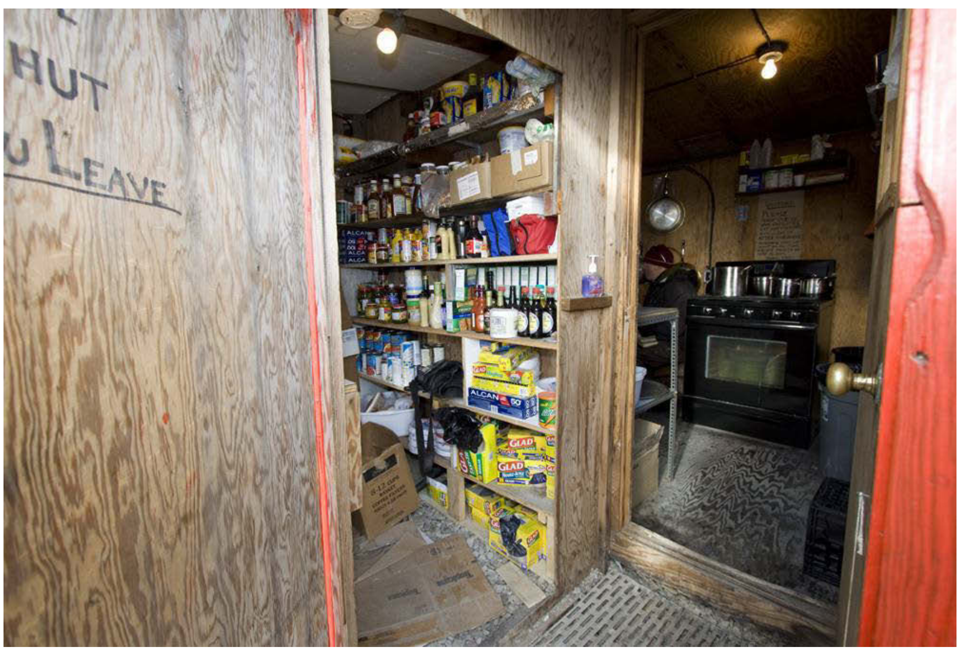

Figure C28. Interior view of kitchen entry, G8.

Figure C29. Interior view of kitchen pantry, G8.

Figure C30. Interior view of kitchen, G8.

Figure C31. Interior view of kitchen, G8.

Figure C32. Exterior view of Storage Shed, G9.

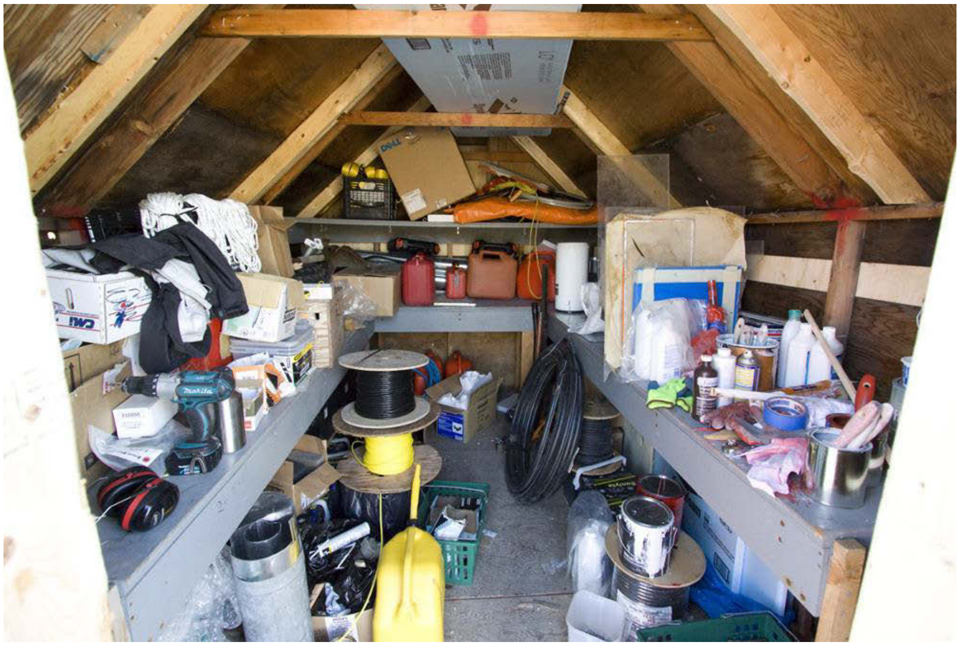

Figure C33. Interior view of Storage Shed, G9.

Annex D. Camp Electricals

This annex provides a brief overview of the electrical set up in the camp.

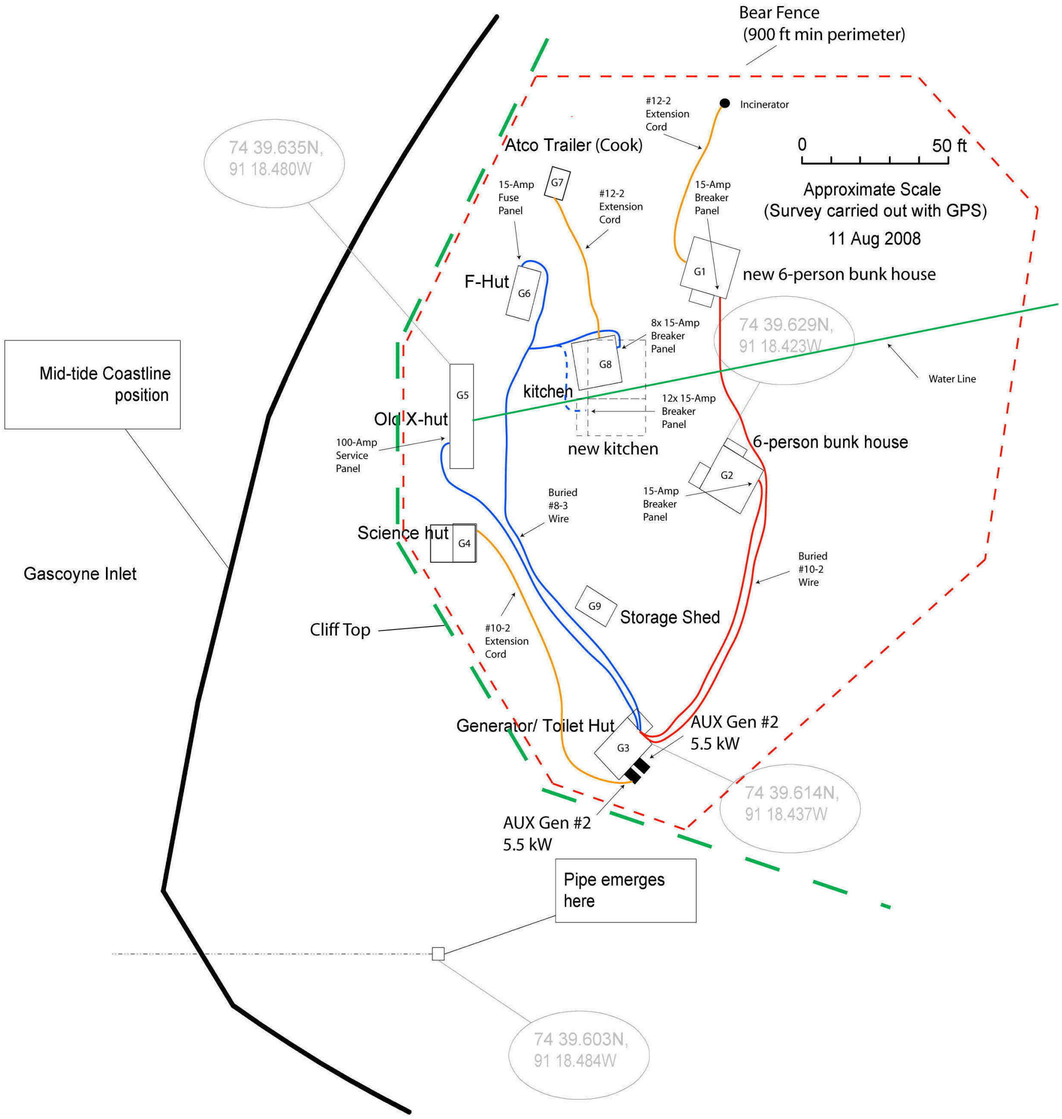

Figure D1. Overview of underground wiring at Gascoyne Inlet Camp.

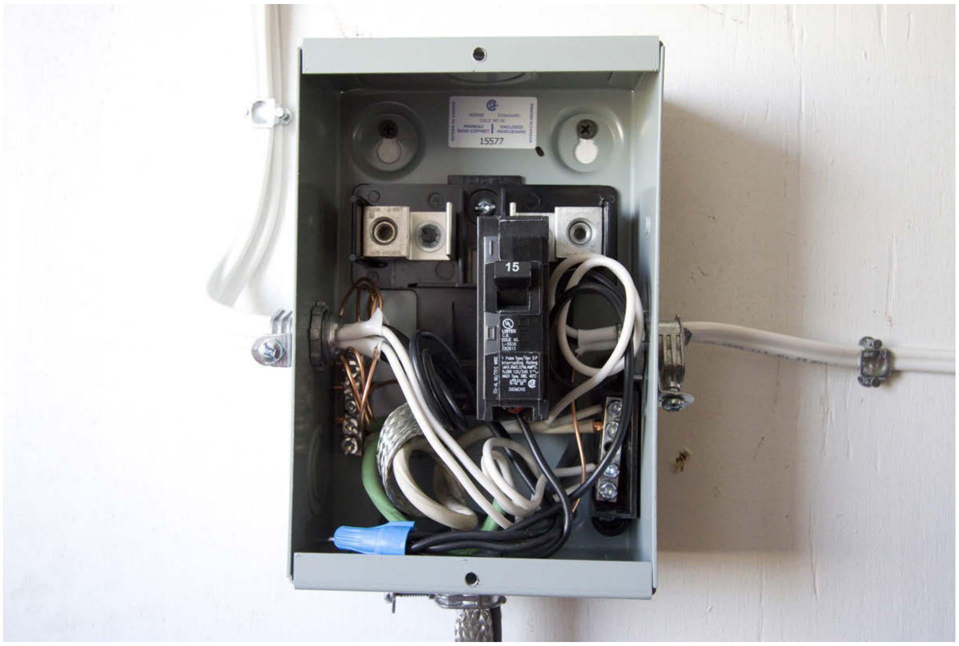

Figure D2. Bunkhouse G1 electrical panel box.

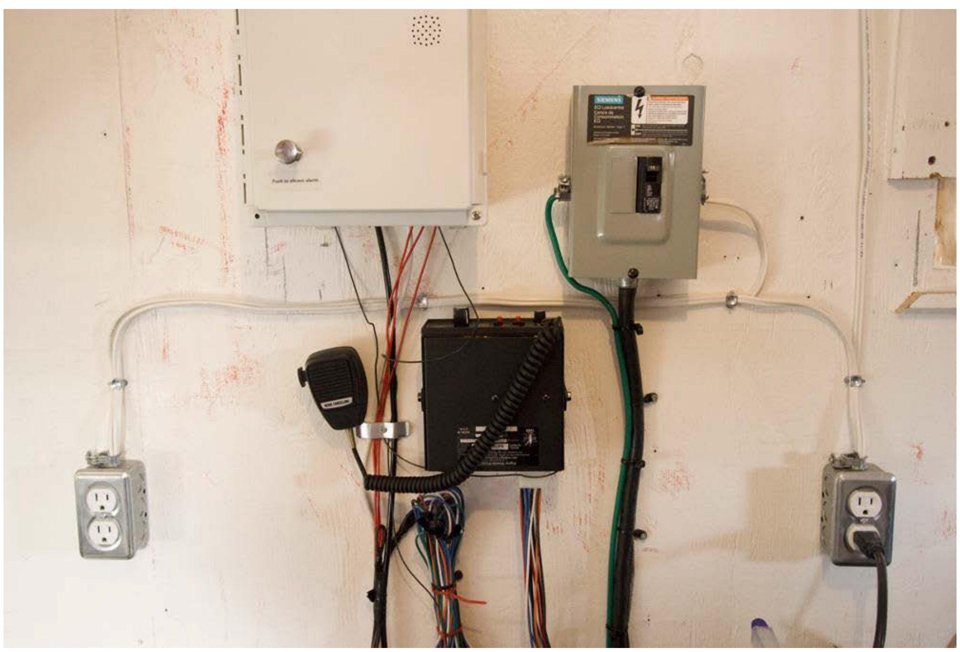

Figure D3. Electrical Panel Blockhouse G2.

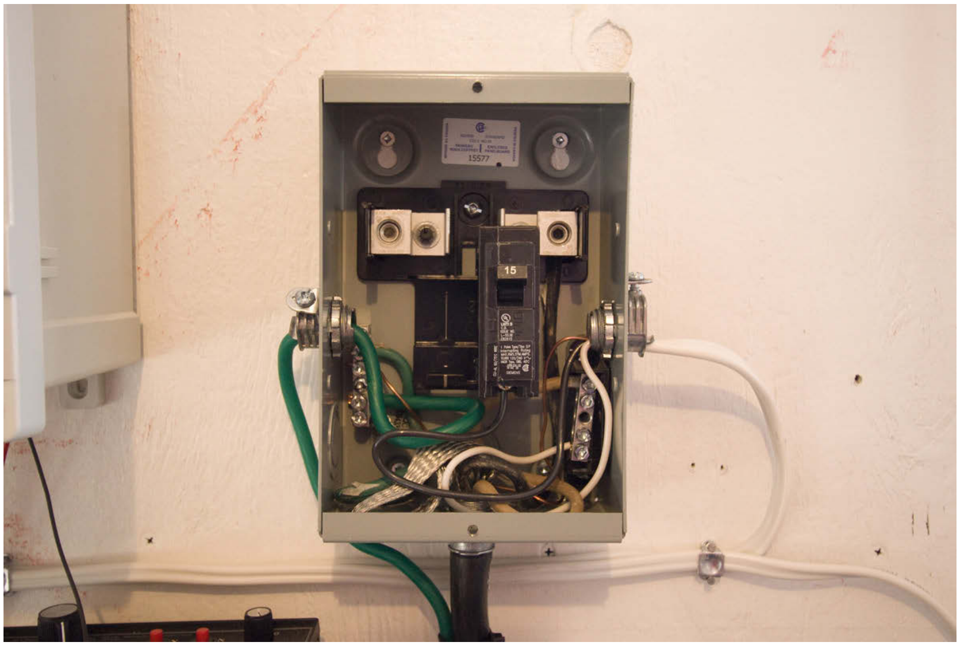

Figure D4. Bunkhouse G2 electrical panel box.

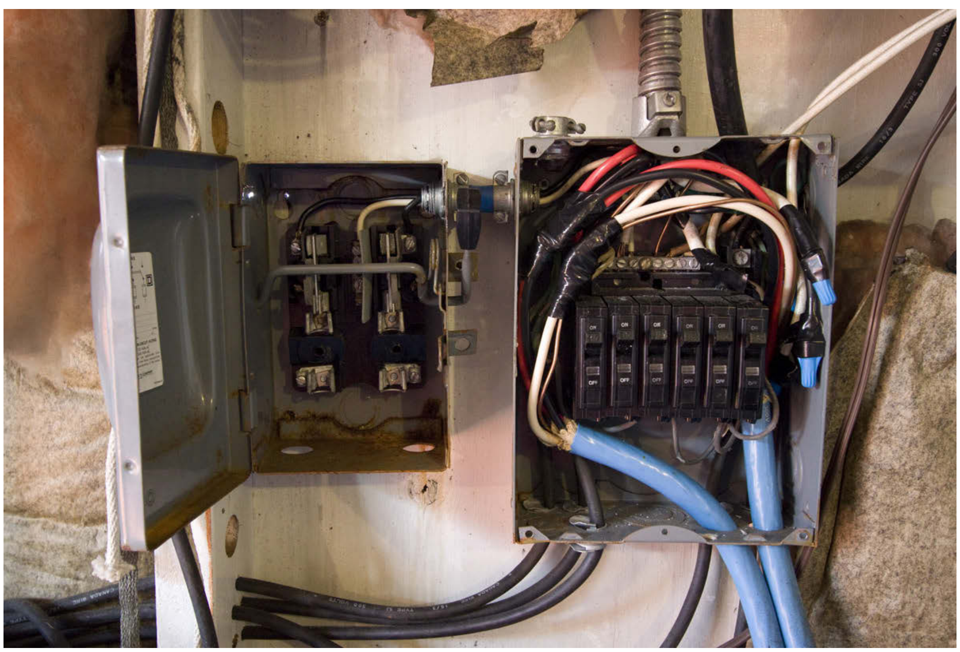

Figure D5. Generator Hut building G3 main electrical panel.

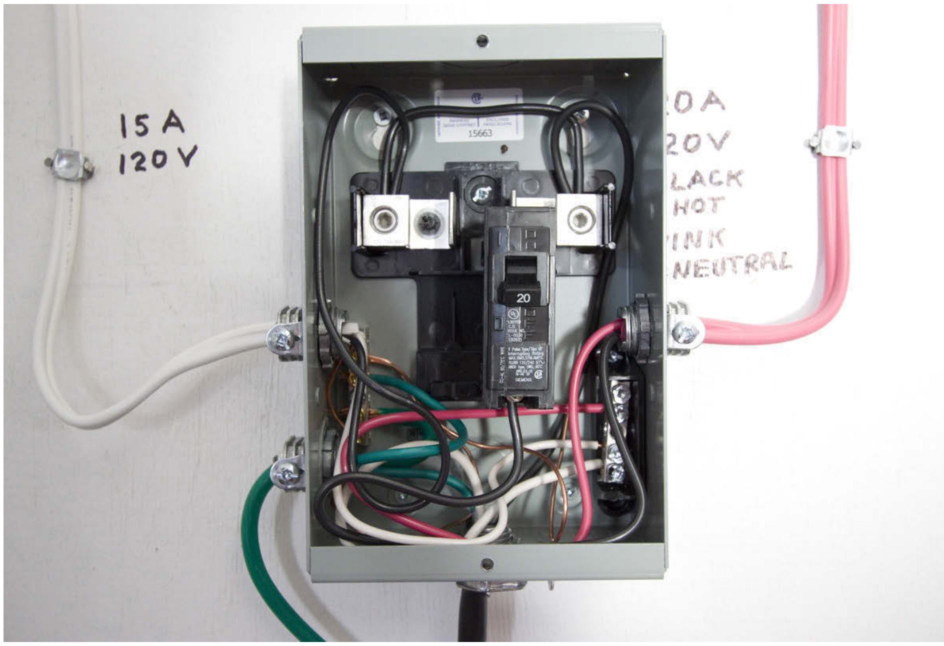

Figure D6. Science Hut building G4 electrical panel.

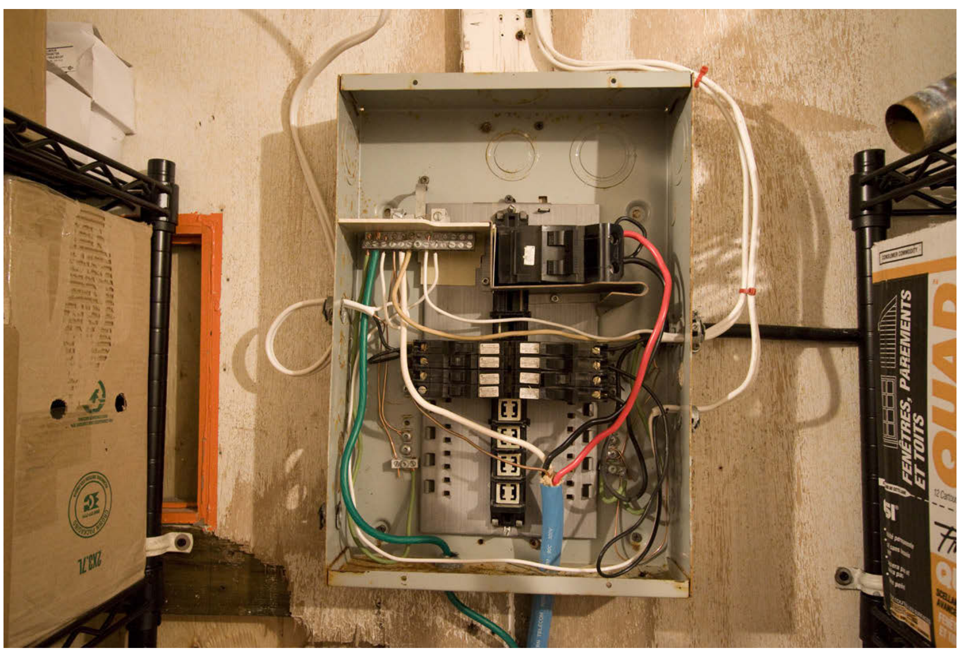

Figure D7. Storage hut building G5 electrical panel.

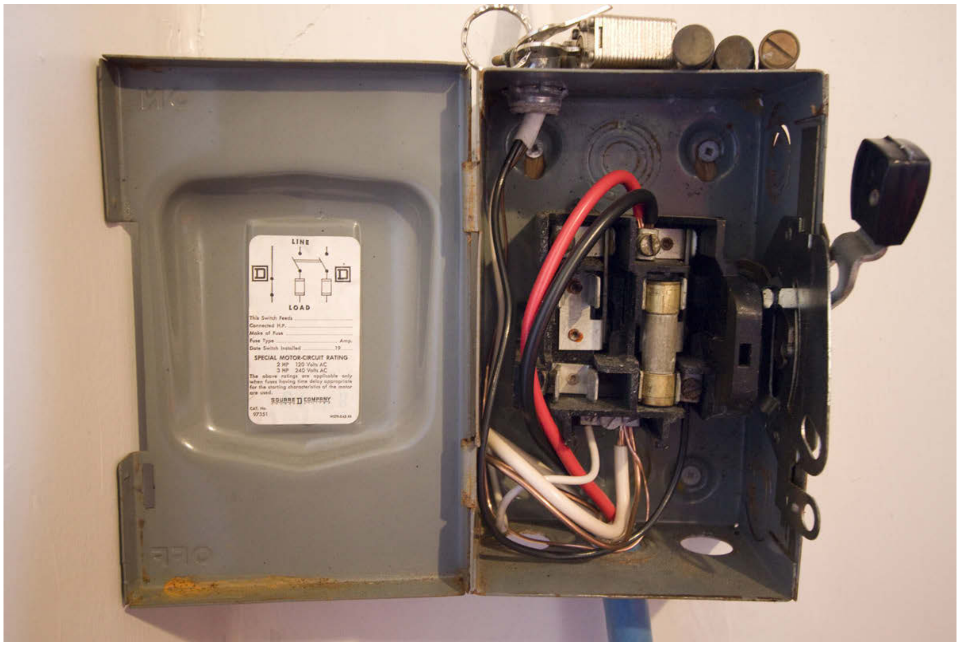

Figure D8. F-Hut building G6 electrical panel box.

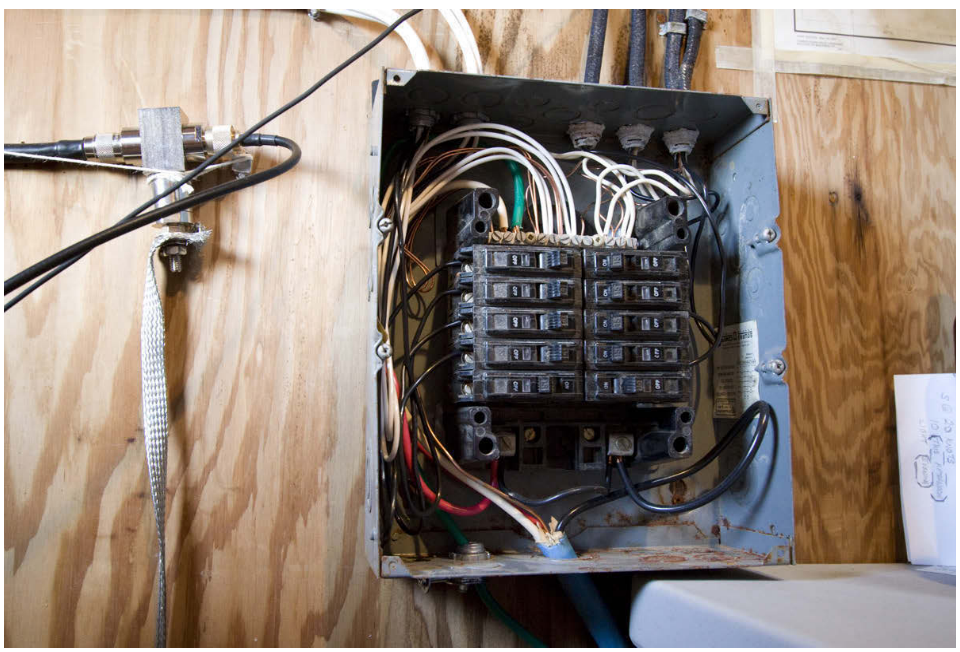

Figure D9. Kitchen building G8 electrical panel.

This page intentionally left blank.

Annex E. Water Usage

According to the water flow meter installed on our water intake line we used 4007 Imperial Gallons in twenty-nine days. This is the equivalent of 18.22 m^3 indicating a camp average usage of 0.628 m^3/day; significantly less than our allowed 5 m^3/day.

With 364 person-days to date, this implies a water usage rate of 0.0500 m^3/day (50 L/day or 11 Imp. Gal/day) for each person.

This page intentionally left blank.

Annex F. Safety and Security

This annex provides the safety reports for the construction and main phases of the summer field trial.

The pre-trial safety report is included in its entirety, but the main trial report is not embedded fully because of the length of the document. Instead the Safety Officer's recommendations are copied to this document. There were no significant issues arising during the main trial.

Construction Phase Report

From:	Shepeta, Val
Sent:	Wednesday, July 29, 2009 9:53 AM
To:	O'Grady, Sean; Wile, Dan
Cc:	McCoy, Nelson; Heard, Garry
Subject:	FSO report.doc

Northern Watch Technology Demonstration Project

Safety Report

June-July 2009

Pre-Trial Camp Setup

June 28, 2009. Resolute

Upon arrival in Resolute we checked the containers for the existing bear fence. None was found. J. Rouleau acquired shotguns and ammunition, bear spray, bear scare pens and charges. J. Rouleau conducted training on bear scare pens for V. Shepeta, M. Baldin, I. Pereza, and D. Clark. Received one SSB 4.5MHz HF emergency radio, two Iridium phones from Polar Shelf. Everything has fully charged batteries. Checked HF and Iridium COMS. All in working order. Charged and checked VHF iCom radios – OK.

July 1, 2009. Gascoyne

- We held a meeting on bear safety protocol. Briefing by J. Rouleau on bear safety procedures, and what to do when a bear is spotted. V. Shepeta gave briefing on using satellite Iridium phones.
- Radio 'sked' (scheduled check-in) with Resolute at 7:30am and 7:00 pm each day. They did not hear us on HF 4.5MHz. Contacted Polar Shelf via satellite phone. Reinstalled HF dipole ANT higher on telescopic mast and replaced the batteries.
- Drinking water: Our shipment with the chloride dioxide to treat drinking water did not arrive. We had to use last year's supply of water treatment kits.

- Checked smoke/carbon dioxide detectors and changed the batteries where required. All tested and in working order. Two fire extinguishers are present in every accommodation hut and kitchen and one in the generator hut.
- D. Clark chipped his tooth, but is O.K.

July 2, 2009
- Found the bear fence and set it up around the living quarters and kitchen. The bear fence is armed and tested every evening by V. Shepeta. Issais and Derek tested it by walking through and breaking the wire. The alarm went off when the loop was opened. They then fixed the open wire.
- Trying to improve HF antenna performance. Changed for the third time. There was a little improvement, but nothing major.

July 4, 2009
- The bear fence alarm went off at 7:30 am. Jacques Rouleau and Kevin Whalen secured the area. No wild life was sighted. Suspected a bad wire connection after the last break test. Reworked the wire connections and tested successfully.
- A meeting was held to ensure that everyone was aware of the procedure to be used when using the toilet facility and when disposing of waste, directed by Sean O'Grady. This is necessary to maintain good hygiene and ensure continuity of clean conditions for all.

July 5, 2009
- The new bunkhouse is up. Two fire extinguishers and smoke/carbon monoxide detectors installed. The smoke detector in the new bunkhouse draws too much current from the battery and after two days the service signal is on. The smoked detector was replaced with the one from the ATCO trailer. More detectors are needed.

July 13, 2009
- Derek had a tooth ache. He left early with Jacques to get treatment in Resolute.

Summary:
- Water treatment unit is installed and was connected the last day due to the shipment delay.
- An on-demand propane hot water heating system was installed, as indicated in the Safety Plan: Summer 2009 Pre-Trial Camp Setup, by designated personnel and was operational.
- The Bear Fence; covering all sleeping accommodations/kitchen was installed and armed every night. One hour bear patrol was done twice a day (after breakfast and after supper) by the Camp Security Officer and one of the team members to look for any polar bear signs using ATVs. A company leaving the camp on ATV had VHF iCom radios to maintain COMS with the camp.
- Sleeping Accommodations: The team used the two new 16x16 bunkhouses.

- Radio Communication Capabilities: HF antenna and hardware set up and COM check at the required time. We tried 3 different ANT configurations and one day before HF COM was established with Resolute. Prior to this we used Iridium to confirm that everything was OK. Depending on the weather conditions our transmit signals were poor to none. It may be unreasonable to require that HF COM is established with Resolute before the plane leaves Gascoyne. Two satellite phones for all time communications were provided and were operational all time.

___________________________________Val Shepeta Field Safety Officer

___________________________________Sean O'Grady Deputy Field Safety Officer

___________________________________ Dan Wile Team Leader / OIC

July 29, 2009

Main Trial Safety Report Excerpt

Eric Durling, EMD Security Services Inc.

Safety Recommendations

I will delineate my safety recommendations in point form. This is not an exhaustive list, but a compilation of issues from my own observations and from Gascoyne Inlet Camp participants. In some instances, I investigated issues for safety standards, such as with electricity and fire extinguishers. This list is as follows:

- Investment in better portable radios with a repeater system on the mountain. The current portable radios have no range to the airstrip a ½ kilometer from the Gascoyne Inlet Camp, Radstock Bay, or Cape Ricketts, which are prime polar bear areas;
- ATV helmets are a mandatory requirement and camp participants must either bring their own or wear what is available;
- The garbage bags for the poop buckets are excellent, but were weak in some instances and giving out, resulting in human feces mess. This poses a health problem. My suggestion is to use a similar bag to the current bag, but made of a heavier ply of plastic. In addition, an inside liner bag should be used to capture any unwanted overflow;

- In consultation with the OIC Garry Heard, the fire extinguishers were all new in 2008. When I examined them on August 14th, five of them showed ‘recharge’. However, the next night the two that showed ‘recharge’ in building G-1, were displaying ‘green’ indicating they were fine. Building G-1 was warm with the stove operating when the two fire extinguishers displayed ‘green’. This is more of an observation than a recommendation. This issue should be discussed with the Fire Marshall’s office and the manufacturer to determine if the fire extinguishers are properly working fire extinguishers;
- I discussed the safety of electrical wiring within the buildings of Gascoyne Inlet Camp with Gordon Ebbeson, Electrical Engineering Scientist and Journeyman Electrician. He advised that he replaced all of the bad wiring and the main electrical panel has a proper ground wire. The wiring is now safe. There are two diesel generators with circuit breakers for 30 amps for any electrical malfunction or overload. Gordon said the camp is not compliant with the electrical code by having the wiring stapled onto the walls and onto the ceilings rather than installed inside of the walls and ceilings. The issues are cosmetic in nature and do not compromise safety;
- Gordon Ebbeson examined the original green generator from 1970 (now 39 years old) that is kept in building G-3 and said that it requires some new mechanical parts, but additionally it requires new wiring for safety. The old wiring from the old green generator was removed;
- The PCSP ATV’s that were supplied need new tires. The red ATV Kawasaki 250 machine had no front brakes. The green ATV Kawasaki 220 needs new electrical wiring in the rear harness, where the fire occurred;
- Warmer hand gloves are required for on the water while working on the CCGS Terry Fox. While I was present on August 15th, Dan Hutt, Al Tremblay, Gordon Ebbeson, Dan Wile, and Garry Heard had cold hands;
- The zodiac boat launch does not have a proper pump to attach to the holes for pumping because an attachment is missing from the stern, one of two holes. Jacques Rouleau stated that the zodiac boat has a small leak and he had to pump it up every day. The zodiac boat needs repairs for safety and serviceability;
- Identification numbers are required for camp buildings for reference on the camp site;
- On August 14th, the two diesel generators ran out of fuel. Six camp participants were aboard the CCGS Terry Fox and four persons remained

within the camp. The oversight was due to no Camp Manager. As the CSO, I assumed the duty of refueling all fuel tanks from this point forward. Recommendation is that a Camp Manager position be employed in the future;

- The burn incinerator requires hinges for the top lid for safety reasons. When burning, the lid becomes too hot. With hinges and a hood rod, this safety measure will prevent anyone from burning their hands;
- Rubber bullets and the appropriate weapon to discharge rubber bullets are required as per Nunavut Conservation Officer, Melanie Howell.

List of symbols/abbreviations/acronyms/initialisms

ABS	Acrylonitrile butadiene styrene
ACR	Array Controller Receiver
AEL	Array Element Localization
AIS	Automated Identification System
ATV	All Terrain Vehicle
BGAN	Broadband Global Area Network
BIO	Bedford Institute of Oceanography
C2	Command and Control
CCGS	Canadian Coast Guard Ship
CPA	Closest Point of Approach
DND	Department of National Defence
DRDC	Defence Research and Development Canada
DSL	Digital Subscriber Line
FRAZ	Frequency Azimuth
FRC	Fast Rescue Craft
GPS	Global Positioning System
HF	High Frequency
MCP	Matched Correlation Processing
NW	Northern Watch
OIC	Officer In Charge
PCSP	Polar Continental Shelf Project

PEX	Cross-Linked Polyethelene
PVC	Polyvinyl Chloride
RHIB	Rigid Hull Inflatable Boat
ROV	Remotely Operated Vehicle
SP	Shore Patrol
TDP	Technology Demonstration Project
UW	Underwater
UEP	Underwater Electric Potential
UPS	Uninterruptible Power Supply
US	Underwater Sensing

This page intentionally left blank.

Distribution List

Document Number: DRDC Atlantic TM 2010-241

List Part 1: Internal Distribution by Centre

1	Garry J. Heard
1	Nicos Pelavas
1	Derek Clark
1	Dan L. Hutt
1	Isaias Peraza
1	George Schattschneider
1	Derek Clark
1	Val Shepeta
1	Jacques Rouleau
1	Bruce Grychowski
1	David Hazen
1	Calvin Hyatt
3	DRDC Atlantic Library
15	**TOTAL LIST PART 1**

List Part 2: External Distribution by DRDKIM

1	NDHQ/DRDKIM
	DRDC Corporate, 305 Rideau St., Ottawa, ON K1A 0K2
1	Benny Wong
1	Richard Williams
1	Gary Gelling
	DRDC Ottawa, 3701 Carling Ave., Ottawa, ON K1A 0Z4
1	Dan Brookes
1	Jim Lee
1	Chen Wu
1	Michael Low
	DRDC Valcartier, 2459 Pie-XI Boulevard North, Val-Belair, QC G3J 1X5
1	J. L. Forand
1	Vincent Larochelle
1	G. Tardif
	CORA, 101 Colonel By Dr., Ottawa, ON K1A 0K2
1	Matthew McLeod
1	Library and Archives Canada, Attn: Military Archivist, Government Records Branch
13	**TOTAL LIST PART 2**

28	**TOTAL COPIES REQUIRED**

This page intentionally left blank.

DOCUMENT CONTROL DATA

(Security classification of title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATOR (the name and address of the organization preparing the document. Organizations for whom the document was prepared, e.g. Centre sponsoring a contractor's report, or tasking agency, are entered in section 8.) DRDC Atlantic 9 Grove St, PO Box 1012 Dartmouth, NS B2Y 3Z7	2. SECURITY CLASSIFICATION (overall security classification of the document including special warning terms if applicable). UNCLASSIFIED (NON-CONTROLLED GOODS) DMC A REVIEW: GCEC JUNE 2010

3. TITLE (the complete document title as indicated on the title page. Its classification should be indicated by the appropriate abbreviation (S,C,R or U) in parentheses after the title).

Underwater Sensor System 2009 Field Trial Report

4. AUTHORS (Last name, first name, middle initial. If military, show rank, e.g. Doe, Maj. John E.)

Heard, G.J., Pelavas, N., Ebbeson, G.R., Hutt, D.L., Peraza, I., Schattschneider, G., Clark, D., Shepeta, V., Rouleau, J.

5. DATE OF PUBLICATION (month and year of publication of document) March 2011	6a. NO. OF PAGES (total containing information Include Annexes, Appendices, etc). 104	6b. NO. OF REFS (total cited in document) 6

7. DESCRIPTIVE NOTES (the category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of report, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered).

Technical Memorandum

8. SPONSORING ACTIVITY (the name of the department project office or laboratory sponsoring the research and development. Include address).

Defence R&D Canada – Atlantic
PO Box 1012
Dartmouth, NS, Canada B2Y 3Z7

9a. PROJECT OR GRANT NO. (if appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant). Northern Watch TDP	9b. CONTRACT NO. (if appropriate, the applicable number under which the document was written).
10a ORIGINATOR'S DOCUMENT NUMBER (the official document number by which the document is identified by the originating activity. This number must be unique to this document.) DRDC Atlantic TM 2010-241	10b OTHER DOCUMENT NOs. (Any other numbers which may be assigned this document either by the originator or by the sponsor.)

11. DOCUMENT AVAILABILITY (any limitations on further dissemination of the document, other than those imposed by security classification)

(X) Unlimited distribution
(   ) Defence departments and defence contractors; further distribution only as approved
(   ) Defence departments and Canadian defence contractors; further distribution only as approved
(   ) Government departments and agencies; further distribution only as approved
(   ) Defence departments; further distribution only as approved
(   ) Other (please specify):

12. DOCUMENT ANNOUNCEMENT (any limitation to the bibliographic announcement of this document. This will normally correspond to the Document Availability (11). However, where further distribution (beyond the audience specified in (11) is possible, a wider announcement audience may be selected).

13. ABSTRACT (a brief and factual summary of the document. It may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall begin with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (S), (C), (R), or (U). It is not necessary to include here abstracts in both official languages unless the text is bilingual).

This document provides an overview of the summer 2009 field trial conducted at Gascoyne Inlet on Devon Island, Nunavut. The trial was carried out as part of the effort related to the Northern Watch Technology Demonstration Project. This report describes the progress against the objectives of the field trial and is intended to serve as a reference to the Gascoyne Inlet field camp, which was greatly improved and extended during this field trial. The main scientific objective of the trial was the deployment of two underwater sensing arrays in Barrow Strait. The deployment was successfully completed and sizeable quantities of valuable data were collected. Unfortunately, the underwater arrays suffered a mechanical issue that allowed water to penetrate and render them inoperable after a period of time. It had been the intention that these arrays would be reactivated in future field trials at this location.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus. e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus-identified. If it not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title).

Northern Watch, Gascoyne Inlet Camp, Underwater Acoustics, Hydrophone Arrays, Array Deployment, Array Recovery, Foreshore Pipe, AIS, Matched Correlation Processing, Ambient Noise, Transmission Loss, Communications, Power Usage, Camp Building Layouts, Camp Electricals

This page intentionally left blank.

Defence R&D Canada

Canada's leader in defence
and National Security
Science and Technology

R & D pour la défense Canada

Chef de file au Canada en matière
de science et de technologie pour
la défense et la sécurité nationale

DEFENCE DÉFENSE

www.drdc-rddc.gc.ca